Hundred Year Motion of the Geomagnetic Field for the 1960-1965 Period

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Preface

The goal of this work is to present the distribution of hundred year variations on the Earth's surface as close to the actual ones as possible. The results are given in the form of isoperiodic maps, value tables of average yearly magnetic element changes for the five year period, 1960 - 1965; also provided are coefficient tables taken from the isoperiodic charts obtained by a spherically harmonious analysis method. This data may be utilized with the composition of magnetic charts for the presentation of magnetic observation results to the general period and for the development of basic principles of magnetic field change of the Earth.

Even though the amount of information necessary to obtain hundred year variations is becoming more plentiful, accompanied by an increase in quality, nevertheless, it is still insufficient in terms of accurate isoperiodic chart compilation. The results remain schematic ones. Therefore, we found it expedient to utilize two methods of isoperiodic chart compilation--graphic and analytic.

At IZMIRAN in 1960, world isoperiodic charts were compiled for the 1954 - 1959 period. Basic sources for their compilation were the average yearly values in 90 magnetic observatories. These values were very asimilar in quality. Continuous, uninterrupted series of yearly average values obtained during the last years of the five year period were received only by a very limited number of observatories.

Quite often these series were broken during the first years and also experienced were interruptions in absolute values due to the shifting of observatories etc. But the basic difficulty in using these observatories for the compilation of isoperiodic charts consisted of their unequal distribution on land surfaces. Approximately 50% of the observatories were concentrated in Eurasia, while in Africa, Australia and especially Anarctica, their quantity was negligible.

Even more unfortunate was the case of oceans, for which almost no data existed at all. Therefore, the 1954 - 1959 period provided only a schematic picture of the distribution values of the magnetic motion (SV). Even this data was a certain forward step compared to what was gathered for earlier periods.

I. Isoperiodic Chart Compilation by the Graphic Method.

1. Initial Data

The 1960 - 1965 world isoperiodic charts were compiled in 1966 - 1967. For their compilation, as original material, yearly average values of magnetic elements were utilized [1, 2, 3]. Data concerning this subject were transmitted through V. P. Orlov, who acted as a representative of the hundred year variation commission no. 3, of the International Association of Geomagnetism and Aeronomy. A total of 126 observatories participated and their yearly average values were utilized.

The location of these magnetic observatories whose data was used are shown on a schematic chart (Fig. 1 and 1-a). The tables of values for average yearly magnetic changes for the 1960 - 65 period are given in the supplement (supplement 1).

The considerable increase in the quantity of magnetic observatories, whose yearly average values we placed, made it possible to obtain a picture of distribution values SV essentially more complete and reliable than for the 1954 - 1959 period. However, even the 1960 - 1965 period data concerning the oceans was inadequate.

The southern band of the Pacific Ocean is an area without much data. This line extends east of the Hawaiian Islands (Honolulu), the Samoan Islands (Apia), New Zealand (Amberly) and continues to the American continent. There are no observatories in these regions.

Since value SV, obtained by way of linear interpolation for such a distance was considered unreliable, we found it expedient to compile isoperiodic charts besides the data given by the magnetic observatories. This was done by taking the SV value in the magnetic observations, the spherically harmonious analysis to n = 6 by a selection method of the optimal spectrum, described in [4] and by its coefficients made a synthesis calculation of the SV value for a network of points, encompassing all of the Earth's surface. Part of these values (mainly for oceans) were utilized by us as supplemental material. In Table 1 are given coefficients obtained with the common solution (x + y + z) for values δx, δy and δz in the magnetic observatories. These notations correspond to the permeated coefficients.

Table 1

Analysis coefficients of sample values δx, δy and δz obtained by magnetic observations.

n,m	δg_n^m	δh_n^m	n,m	δg_n^m	δh_n^m
I.0	22.5		5.0	I.4	
I.I	-	-2.I	5.I	-	0.9
2.0	- 27,6		5.2	I.8	3.0
2.I	3.I	-II.3	5.3	-	-
2.2	-	-I3.2	5.4	-	-
3.0	- 0.9		5.5	0.7	2.2
3.I	- 8.7	4.4	6.0	-0.8	
3.2	I.3	- 0.4	6.I	-	- I.3
3.3	- I.4	- 8.4	6.2	I.2	-
4.0	0.3		6.3	3.0	I.3
4.I	-	2.6	6.4	-	- 0.5
4.2	- 4.7	0.4	6.5	-	- I.2
4.3	-	2.I	6.6	-0.8	-
4.4	- 2.7	- 3.3			

Although the analysis results of the following synthesis was used, we obtained the SV value for all districts on the Earth's surface, however this could not be accepted as completely reliable. The spherically harmonic analysis conducted with a small number of unevenly distributed points could give an incorrect, unusable motion value for distant regions separated from the observation area by thousands of kilometers.

Presented as additional and supplemental materials were tables with SV values and isoperiodic charts with different countries (U.S., Canada, Australia and others). The results of secondary observations of "Zarya" in its voyages of 1957 - 1958 and 1964 - 1965 in the Atlantic Ocean were also presented.

Canadian isoperiodic charts [5] encompass all the Dominion territory with contiguous parts of the U.S. and oceans. In the compilation of these charts, the data of magnetic observations were utilized from a large number of secondary points in Canada and the United States. Data of magnetic observations in the USSR, Scandinavia and Greenland was also utilized. However, this information did not completely cover the five year period of 1960 - 1965. By secondary posts, the data was limited to 1962.

The values of magnetic observations obtained by us for the full 1960 - 1965 period clearly showed that Canadian isoperiodic charts give these motion values with certain errors. But for the configuration of isoperiodic lines, we partially used these charts.

Australian isoperiodic charts [6] were compiled by magnetic data observations and a small number of secondary posts. To a large extent, they are of a schematic nature. As a rule, data to 1962 was used in their compilation. To a certain extent, therefore, they have a prognostic character and do not conform to our data for the full 5 year period.

Data obtained by "Zarya" is by accuracy (approximately 50 - 100γ) is considerably less than stationary, permanent magnetic observatories. However, with an observation interval of 5 and in certain cases, up to 7 years, averaging several close crossings, it was possible to judge the approximate δH and δZ values and estimate that the SV value of these elements is great and oceanic interpolation is uniform. We could not regard as reliable, the comparison of values on separate crossings. In this case, the determination accuracy of the observation location was 2 - 3 miles, namely the values of a secondary post (crossing) could be regarded as ones dispersed up to 5 miles (and in some cases even more). The difference in values of two crossings could depend not only on the magnetic motion and accurate measurements, but could essentially alter due to the anomaly of inaccurately coinciding locations. Since these alterations had an obviously accidental character, averaging out the results in several neighboring crossings, the error substantially decreased. The main significance of "Zarya" data, notwithstanding its lesser accuracy, was that they concerned aquatic regions, for which other data was almost negligible.

After the compilation by graphical methods of a working varient of isoperiodic charts, data from Sputnik "Cosmos 49" were brought and compared with marine data of "Zarya" and "Vim" and other aeromagnetic information of "Magnit". For Australia, this was compared with data from satellite "Avangard III" [7].

It cannot be expected that every comparison for every separate location would produce a reliable value motion δT, since the values of "Cosmos 49" at altitudes of 300 - 400 km were free from local, and for the most part regional magnetic anomalies which may be observed from the surface. These anomalies entered into the difference with the satellite observations and could substantially reflect on the accuracy of the obtainable results. However, even in this case of averaging results for a series of posts would bring a substantial decrease in error of an accidental nature. Such averaging occurred, as a rule with ten-degree trapeziums and showed that the motion value with an accuracy of 20γ, and in some cases even higher, may be obtained. For vast areas of oceans, where more accurate data concerning motion value is lacking, the use of satellite data is expedient. Considerably more reliable δT values were obtained with comparison of data from "Cosmos 49" and Avangard III" over Australia. Data from both satellites did not alter with magnetic anomalies and gave SV values for tension modules (δT) with an accuracy of first gamma units. Unfortunately, they do not give motion value for other elements [8].

As a result of utilizing these supplementary data, it became apparent that initial materials used for compiling isoperiodic charts of various elements were not identical. More complete initial materials were shown by elements δT and δD. Other elements were less complete, but in every case the materials were homogenous. As a rule, they were sufficiently detailed for Europe, but in varying detrees, were not sufficiently detailed for other continents and oceans. In connection with this, it became clear that isoperiodic charts compiled by the graphic method in different regions on the Earth's surface will have different accuracies. Uniform accuracy can be achieved only by roughening the isoperiodic chart or leaving out portions of the SV values in regions secured with initial data. However, for an improvement, we selected this direction for the sake of attaining formal homogenty for expedient reasons. Supplemental materials introduced by us for purpose of utilization in spherical analysis, as a rule, was not possible, since values δT, δD, δH for various posts could not be presented in a vector form (δx, δy, and δz). Results of analytic calculations by data obtained only from observations, giving a general schematic picture of the whole Earth, were given for regions not secured with data and consisting of less accuracy. Therefore, in general, charts compiled with a graphic method should have a higher accuracy than the results of analytic calculations.

2. Isoperiodic Chart Compilation

In the capacity of cartographic basics for the compilation of isoperiodic charts, blank maps of the world were used. The mercator projection on a scale of 1:100,000,000 for the equator and maps of the northern and southern hemispheres in the Central azimuth projection on a scale of 1:50,000,000 were utilized. The selection of two cartographic types was made due to the fact that Mercator projection blanks remain unchanged near the Polar regions, while the zones of high latitudes are severely distorted. The hemispheric blanks on the other hand, have no distortion at high lattitudes while the equatorial zone is severely altered. Besides that, the equatorial section is divided into two blank parts.

Corresponding with initial data δF for six elements (δD, δH, δZ, δT, δX and δY) by data of the magnetic observatories were imposed on the working blanks (on both projections). With similar blanks on a Mercator projection from latitudes 80° North to 80° South, δx, δy, δz and δT values were applied, which were obtained with the analytical method by way of coefficients given in Table 1.

Using this data, together with the supplementary material, an isoperiodic line was constructed for each element independent of each other by the graphic method. When two lines of the two projections were in agreement with each other, for latitudes of 60° North to 60° South, the Mercator projection was favored, while the central azimuthal projection was favored from 60° to 90° north and south.

Depending on the completness of the data, their accuracy and gradients, the interval between neighboring isoperiodic lines, 2' for δ D was selected with unloading in regions near the poles, 10γ for δ H with an interval increase to 20γ in the southern half of the Atlantic Ocean and adjoining parts of the Indian and Pacific Oceans; 20γ for δ X and δ Y with a construction of supplementary lines in a series of regions through 10γ ; 20γ for δ Z and δ T with the addition of 30γ isoperiodics in the northern half of the northern hemisphere.

The data of "Zarya" and satellite "Cosmos-49" had essential values for obtaining the SV picture in the Atlantic ocean. However, in the Indian Ocean, SV values for elements δ Z and δ T were less conclusive.

These values in the Port-au-France observatory on the Kergelen island sharply differed from conforming values at the Hermanes, Mauritius, and on the Antarctic shores, but corresponded fairly well with the magnetic observations of Keuper. Again the insertion of data from "Zarya" allowed acceptance of the "tongue" of high values extending from the Sond islands to the south-west, different from the values on continents surrounding the Indian Ocean. The most difficult part to obtain, due to lack of data, was the region of the southern half of the Pacific Ocean. Here from New Zealand to South America for several kilometers there are no magnetic observatories. "Zarya" crossed several old voyages of the "Carnegie" in the Pacific Ocean.

By these secondary observations, isoperiodic charts were compiled by B. M. Matveev, giving a total motion for approximately 50 years. We had to investigate the possibility of utilizing data of such a long period for a much shorter time span of 1960 - 1965. For such an assignment, we constructed the graphics of vectors δ H and δ T for SV for every 5 years (Fig. 2). These were for stations surrounding the Pacific Ocean (Caccioca, Takson, Honolulu, Apia, Pilar and Amberly). It was discovered that for Caccioca, Takson and Honolulu, during a period of 50 years the SV vector, by dimensions as well as direction were essentially changing. On the contrary, for Pilar, Amberly and Apia, these factors changed only negligibly. Besides that, the vector direction agreeably pointed to the Pacific Ocean region near the tip of South America. This made it possible to form a deduction that the region of maximal values of δ T and δ Z on the Antarctic shores, stretches into the Pacific Ocean to the west of South America. The SV values in this region may be somewhat larger than ones obtained by linear interpolation between the Pilar and Amberly stations. Furthermore, the results of "Zarya" and "Carnegie" for a 50 year period in this region may be utilized for a five year time lapse from 1960 - 1965.

The independently compiled isoperiodic charts of various elements were subjected to qualitative comparison on the logic of the reciprocal location of the regions for extreme values. The consequence was found to be quite satisfactory. The quantitative comparison was conducted by formulating different calculations:

$$\delta X = \cos D\,\delta H - H\sin D\,\sin 1'\,\delta D$$
$$\delta Y = \sin D\,\delta H + H\cos D\,\sin 1\,\delta D$$
$$\delta T = H/_T\,\delta H + Z/_T\,\delta Z$$

The results established that principle SV situations for δ X, δ Y and δ T by charts completed independently of each other and by the calculated values were identical. Quantitative divergence, exact as a rule for oceans more than continents, but as a whole they lie within the limits of accuracy. This does not exceed, even in separate locations 20 γ , while averaging consists of only gamma units.

Satisfied that a sufficient correspondence of isoperiodic charts of various elements by δ H and δ Z values was obtained, we utilized the differential formula $\delta I = \frac{(H\delta Z - Z\delta H)\cos^2 I}{H^2 \sin 1'}$ and calculated value I for a network of points through 10° with Υ and X and compiled isoperiodic maps δ I with these values.

The accuracy evaluation of these isoperiodic maps presents substantial difficulty. First of all, the Earth's surface is quite large, with non-uniform data and therefore, for every element of various regions, it is different. Secondly, there are no strict evaluation methods for regions in which no SV data is available.

The correspondence of various element values is only an individual indication and allows evaluating accurately only to a certain degree of probability. Obviously, even in regions of extreme SV values, located in oceans, an error exceeding 20 γ in yearly dimension changes is not probable, although in isolated cases, it is possible. These same errors are possible where the linear interpolation was made in regions of large SV gradients.

These are areas of the southern half of the Indian and Atlantic Oceans, where SV gradients are large and the southern half of the Pacific Ocean, where the gradients are not so large, but the distances between magnetic observatories are great.

The final results of the graphic method utilization for presenting magnetic motion variations on the Earth's surface are given in isoperiodic maps of average annual changes of the magnetic field for seven elements: δD, δI, δH, δZ, δX, δY, and δT (Fig. 3 - 9) and tables of average annual changes for network of points through 10^{o} with φ and λ (supplement P).

Isoperiods for each element are given, presented by their maps: in the Mercator projection between 70^{o} north and south, in the central azimuthal projection, North and South polar caps in between 40^{o} to 90^{o}.

In comparing the SV in five year periods of 1955 - 1960 and 1960 - 1965 the main features remained similar. However, in a number of regions the SV values noticeably changed.

The basic principle of the entire magnetic variation is manifested in a general decrease of the magnetic field tension in the whole world. This field decrease does not occur identically over the Earth's surface. With a significant decrease in tension in the southern hemisphere, there is an increase of growth in the northern hemisphere. However, a decrease to 140 - 150 γ in the south causes only a growth of 40 γ a year in the north. Qualitatively, this SV factor corresponds to a decrease in the Earth's magnetic movement as a whole and at the same time to the replacement of the eccentric dipole to the north. Besides the change of SV values in the extreme zones, complicating the matter is a number of regions on all maps of all elements is seen a tendency to replace the isoperiodic lines to the west. There is a definite western drift in connection with the isoperiodic maps of the preceeding five year period. We note here an important change.

1. Maximum δ Z and δ T observed during a 5 year period in the Caspian Sea region gradually diminished, beginning in the 1935 - 40 period and mixing to the north, smoothened out completely. At the present time, a weak maximum of δ Z and δ T (+40 - +45) is observed only in the Antarctic region.

2. The δ Z and δ T decrease in the Atlantic Ocean with a center of 10^{o} - 20^{o} latitude became more active: δ Z instead of 100 γ a year reached 150 γ , δ T instead of 70 γ reaches 100 γ .

3. δ Z and δ T values decreased in the Indian Ocean, in the vicinity of Kergelen Island.

4. δ X value increased in the northern half of the Atlantic Ocean.

5. Zero isoperiods δ Y and δ X in Eurasia were displaced approximately 10^{o} to the West. Corresponding with this, the positive values δ D practically for all European territory and contiguous parts of theAtlantic Ocean experienced a decrease.

6. Due to SV, a rapid displacement of magnetic poles is observed, with the northern one going north and the southern one in a northwest direction. Evidently, during the latter years, the south magnetic pole will change from the Antarctic continent into the Indian Ocean.

In general, the picture of magnetic motion of the Earth during the 1960 - 1965 period becomes more complex. However, this complexity may be explained by the fact that more SV data for this period was available; the data was also more accurate than before.

These isoperiodic maps and tables of yearly changes are recommended for practical utilization with the presentation of magnetic observation results of various years during the 1960 - 1965 period. This also applies to the re-compilation of magnetic maps (world-wide or taking in large areas of the world's surface) for the new period. However, it should be noted that these isoperiodic maps, compiled independently for each element do not appear as potentially agreeable to the first gamma units. The non-conformance between isoperiodic maps of separate elements remained undecreased.

We did not consider its removal as expedient, since with this method, the use of additional material would be precluded, and only the data of magnetic observations could be used. This would also change the true picture of the matter, if corrections were made for the conformance among elements.

Analytical SV Presentation

An incomplete potential agreement of isoperiodic maps of various elements compiled by graphic method, limited their use with analytical calculations. Therefore, we considered expedient with δX, δY and δZ values, taken from isoperiodic maps of these elements and compiled by the graphic method to conduct a spherically harmonic analysis. Then to obtain the coefficients of decomposition and to perform a synthesis with these coefficients, the values of δX, δY and δZ and δT.

The analysis was performed in two variants of $n = m = 6$ with δX, δY and δZ values taken from the "graphic" isoperiodic maps. In the first variant, the δX, δY and δZ values were taken for 105 points and the analysis with SV values of 3 elements was conducted at the same time. In the second variant, values were taken in 282 points for every element: the coefficient values for every element were obtained separately and then an average was made. The coefficient values in both variants were obtained close to one another, however, the divergence of the synthesized values from the initial is somewhat lower for the first one and therefore, we selected it for utilization. The $(x + y + z)$ coefficients obtained by analysis are shown in Table 3.

The δX, δY, δZ and δT values were synthesized by these coefficients for a network of points through 10° with φ and λ. With such a thick and correct network of points, the compilation of maps was not difficult. We made this and the maps (graph-analytical ones) are presented in Fig. 10 - 13.

Table 3

n,m	δg_n^m	δh_n^m	n,m	δg_n^m	δh_n^m
I,0	I8,6	-	5,0	0,8	-
I,I	7,7	- I,2	5,I	0,0	0,4
2,0	- 25,I	-	5,2	I,I	2,0
2,I	0,I	-I0,2	5,3	- 0,5	- I,4
2,2	- I,2	-I4,5	5,4	- I,I	0,3
3,0	0,8	-	5,5	- 0,2	- 0,5
3,I	- 8,9	4,I	6,0	- 0,5	-
3,2	0,0	0,I	6,I	0,7	- 0,6
3,3	- I,7	- 4,9	6,2	0,7	0,I
4,0	- 0,2	-	6,3	I,5	I,2
4,I	0,3	I,7	6,4	0,0	- 0,6
4,2	- 2,3	0,6	6,5	0,0	0,5
4,3	- 0,0	2,2	6,6	- 0,4	- 0,6
4.4	- I.3	- 2,3			

It is quite evident that these maps cannot be identical with the graphic presentation. The basic features of SV value distribution was reflected in maps of both types. All maximums and minimums were preserved and the larger gradients were prefixed to the same regions. Also evident is the general decrease of δT, if the Earth is examined as a whole. However, the degree of isoline smoothening is essentially different and the value focused in maximal changes are somewhat different. These divergences are explained by the very procedure of map compilation. The smoothing degree in graphic maps changes in relationship to the available data, while graph-analytical maps are homogenous within the entire Earth and their smoothening is determined by a series of lengths, set in their origin (n = m = 6).

The comparison of the maps showed that the average declination of two types of maps (without calculation of value) is

$\Delta\delta X = \Delta\delta Y = \Delta\delta Z = \pm 8\gamma$. The qualitative divergence, with the calculation of values between the two maps δT averages out to 2γ surface. In separate regions, the divergence reaches 20γ and in cases in south-eastern Africa, reached even 30γ. The reason for such divergence in this region is clear: very large SV gradients in this area of Kergelen island on relatively small distances cannot be transmitted by the six harmonies. To take a large number of harmonies lead to an insufficient accuracy of the maps, compiled with limited initial data was not justified at this time.

In relation to the SV correspondence, observed on the Earth's surface, the SV picture presented in graph-analytical maps, evidently does not have preference in comparison with the SV picture in graphic maps. Inversely, in magnetic observation regions and well exposed areas (Europe and contiguous to it, parts of Asia, South Africa and others) it is clearly worse. Its preference is contained in the system of coefficients which may be utilized with computing calculations.

To demonstrate the extent that the coefficient values depend on the arbitrary approach of the authors, we give for comparison, a table of coefficients derived with a series of analyses (Table 4).

In this table are given 3 coefficient variants obtained with analysis by the authors in this work and coefficients by the analysis of Leaton and Cain [10, 11].

Analysis to $n = m = 6$ by δX, δY and δZ values taken by uniform network coordinates in 105 points (analysis by 315 values) the solution is common. The coefficients of the analysis are given in Table 3. These tables are recommended for use as giving , with a potential agreement of SV value, somewhat closer to the SV of graphic maps.

2. Analysis to n = m = 6 by δ X, δ Y and δ Z values, taken by a uniform network of coordinates in 282 points for every element. The coefficients of this analysis are obtained separately for each element and then an average is made.

3. Analysis to n = m = 6 by sample SV values in the magnetic observations, performed by a "spectrum selection" method with a common solution (x + y + z).

4. The coefficients to n = m = 6 by the analysis of Leaton, Malin, and Evans [10] calculated by SV values in 113 magnetic observations by three subsequent approximations. At the time of execution of this work, the SV values for the 1964 - 1965 period were not known. Therefore, the obtained results are to a certain degree, prognostic in nature.

5. SV coefficients to n = m = 6 by the Cain analysis. The SV analysis was conducted jointly with the magnetic field (analysis) by observation data since 1900. For the SV calculation by Cain was (conditionally) taken into consideration that SV changes are approximations of the formula of second order.

This assumption is evidently satisfactory, in general, for the whole period of magnetic field in a 65 year period. This lead to significant SV divergence for the 1960 - 1965 period with the SV values in solid observations.

To clearly indicate the size and regions of divergence, we give two sets of maps $\Delta\delta X$, $\Delta\delta Y$ and $\Delta\delta Z$.

In the first (Fig. 14 - 16) by the isoline systems are shown the difference between SV graphic maps and graph-analytic of the first variant, presumed by us to be the basic ones.

In the second (Fig. 17 - 19) are shown the regions and sizes of extreme divergence of SV values synthesized by the coefficients of 4 of 5 (2 - 5) indicated analyses with the compiled SV maps by graphic methods. In these maps, the regions are limited by the isolines, where divergence with graphic maps exceeds 20 γ . Inside these contours are shown regions of maximal divergences limited by lines with divergence values in multiples of 10 γ . By these maps it is clearly seen that, as a rule, larger divergences are situated in oceans and by δY in South America, where high accuracy data is very limited.

Basic SV Characteristics

The data obtained from the analysis of isoperiodic maps, the analytical SV presentation allowed to calculate certain parameters of interest for the study of geomagnetism a) displacement to the north of the geomagnetic dipole, b) westward drift of the non-dipole field, c) change due to time of the magnetic moment of the Earth's dipole.

The calculation of these characteristics was made by the coefficients δg_n^m, δh_n^m presented in table 3 and coefficients of the analysis completed by Tyurmin and Cherevko in the order of preparation model of international analytical geomagnetic pole [12]

(a) The displacement rate may be calculated by a formula, presented in the work of Nagata [13]. This rate is derived from the expression representing the potential change on the Earth's surface, provided that the dipole that created it is displaced along its axis to the north. On the other hand, the potential change corresponds to the coefficient change $g_2^0 (\delta g_2^0)$, since this coefficient determines the basic pole. Then, inserting all members with R, representing the potential in degree > 2, we obtain:

$$\delta g_2^0 = 2\frac{Mv}{R^2} = -2\frac{v}{R} g_1^0 \quad \text{и} \quad v = \frac{\delta g_2^0}{2g_1^0} R$$

In this case, with $\delta g_2^0 = -25{,}1\ \gamma$/year and $g_1^0 = -30391\gamma$ for the 1960 - 1965 period, we obtain V = -2.6 km/year, which is close to the one in [13] for the 1955 - 62 period.

(b) For the calculation of drift rate of an non-dipolic field, expressions presented in [14] were utilized:

$$v_n^m = \frac{-\delta g_n^m}{m h_n^m} \qquad (1)$$

$$v_n^m = +\frac{\delta h_n^m}{m g_n^m} \qquad (2)$$

$$v_n^m = \pm\frac{\delta c_n^m}{m c_n^m} \qquad (3)$$

$$v_n^m = -\frac{1}{m} \cdot \frac{\delta g_n^m h_n^m - \delta h_n^m g_n^m}{(g_n^m)^2 + (h_n^m)^2} \qquad (4)$$

In the table, which was partially taken from [15], are presented the harmonic rates obtained as averages from the values by formulas (1 - 4).

Table 5

Эпоха n: m:	2 I	2 2	3 I	3 2	3 3	4 I	4 2	4 3	4 4
I. I955-60	-0,26	-0,32	-0,35	+0,08	-0,I4	-0,I9	-0,I0	-0,I7	-0,I4
2. I960	-0,20	-0,32	-0,II	+0,07	-0,20	-0,I3	-0,I2	-0,I5	-0,I7
3. I954-59	-0,I9	-0,2I	-0,20	-0,05	-0,I2	+0,I0	-0,08	-0,07	-0,07
4. I965	-0,I6	-0,33	-0,I4	+0,04	-0,I8	-0,I9	-0,09	-0,I3	-0,I6
5. I960-65	-0,II	-0,I7	-0,46	+0,02	-0,I4	+0,04	-0.08	-0,09	-0,07
g Cp.(I)-(5)	-0,I8	-0,27	-0,25	+0,03	-0,I5	-0,06	-0,09	-0,I0	-0,I2

(1) By data of T. Nagata and Yukutake.

(2) J. Cain and others

(3) Adam, Ben'kova

(4) Leaton and Evans

(5) by authors' analysis in the given experiment.

As seen from this table, the larger values have rates for the first three harmonies: 2 - 1, 2 - 2, 3 - 1, the stable easterly drift has a 3 - 2 harmonic. In general, the rate amount decreases with the growth of the order. The average value by the presented analysis for all harmonies for the 1960 - 65 period is equal to 0.13^{o}/year, less than anticipated earlier, in that number is [15].

(c) The decrease of the magnetic moment of the Earth's dipole was obtained by differentiating with the known time of the expression:

$$\boxed{M/R^3 = \sqrt{(g_1^0)^2 + (g_1^1)^2 + (h_1^1)^2}}.$$

The decrease of the field on the Earth's surface, determined by the decrease in M or $\frac{\Delta M}{\Delta t}\frac{1}{R^3}$ was equal - 19 γ /year, while decrease $\boxed{\frac{\Delta M}{\Delta t} = 4{,}9.10^{22} \text{ cgsm /год,}}$ continues to diminish.

(d) The displacement of the geo-magnetic pole was obtained in time from known relationships: $\boxed{tg\,\lambda_0 = \frac{h_1^0}{g_1^0} \quad и \quad tg\,\theta = \frac{g_1^0}{\sqrt{(g_1^1)_g^2 + (h_1^1)^2}}}$

differentiated by time and the configuration of the corresponding coefficients:

$$\frac{\Delta \lambda_0}{\Delta t} \text{ received } - .06^{\circ} \text{ year } \quad \frac{\Delta \theta}{\Delta t} = .02/\text{year}$$

direction of displacement--north-western.

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Table 4.

	δg_n^m					δh_n^m				
	(I)	(2)	(3)	(4)	(5)	(I)	(2)	(3)	(4)	(5)
I.0	I8,6	I6.4	22.5	I5.5	I3.0					
I.I	7,7	8.7	-	8.3	8.5	- I,2	- 0.2	- 2.I	- 0.6	- I.4
2.0	-25,I	-24.6	-27.6	-26.6	-27.2					
2.I	0,I	- I.I	3.I	- I.3	0.I	-I0,2	-I0.I	-II.3	-II.4	-I6.9
2.2	- I,2	- 0.7	-	I.3	- 6.4	-I4,5	-I5.6	-I3.2	-I8.2	-I6.6
3.0	0,8	0.2	- 0.9	0	I.8					
3.I	- 8,9	- 9.2	- 8.7	- 9.5	-II.I	4,I	4.I	4.4	3.2	6.3
3.2	0,0	- 0.3	I.3	- I.9	4.0	0,I	0.9	- 0.4	I.6	2.9
3.3	- I,7	- 2.2	- I.4	- 0.6	- 6.6	- 4,9	- 5.0	- 8.4	- 8.5	- 7.I
4.0	- 0,2	- 0.I	0.3	0.6	0.9					
4.I	0,3	I.2	-	I.0	I.3	I,7	I.9	2.6	3.0	-2.9
4.2	- 2,3	- 2.2	- 4.7	- 2.2	- 2.5	0,6	I.I	0.4	- 0.7	-0.3
4.3	- 0,0	- 0.5	-	0.2	0.9	2,2	2.0	2.I	2.7	I.9
4.4	- I,3	- 0.9	-2.7	- 3.0	- 3.I	- 2,3	- I.5	- 3.3	- 2.7	- 7.6

Table 4.
(Continuation)

	δg_n^m					δh_n^m				
	(I)	(2)	(3)	(4)	(5)	(I)	(2)	(3)	(4)	(5)
5.0	0,8	0.5	I.4	0.8	2.7					
5.I	0,0	0.0	–	0.4	0.8	0,4	I.I	0.9	I.9	2.8
5.2	I,I	I.2	I.8	I.6	3.7	2,0	I.I	3.0	2.3	2.4
5.3	– 0,5	– 0.2	–	– 0.3	0.5	– I,4	– 0.7	–	– I.8	– 2.5
5.4	– I,I	– 0.6	–	– I.I	0.5	0,3	0.2	–	I.4	0.7
5.5	– 0,2	0.I	0.7	I.7	2.5	– 0,5	0.5	2.2	0.5	– 0.3
6.0	– 0,5	– 0.5	– 0.8	0.0	– I.I					
6.I	0,7	0.4	–	– 0.5	0.7	– 0,6	– 0.5	–I.3	– 2.2	– 0.4
6.2	0,7	0.7	I.2	I.8	– 0.I	0,I	0.4	–	0.2	– 0.6
6.3	I,5	I.0	3.0	I.4	2.2	I,2	I.I	I.3	0.9	I.8
6.4	0,0	0.4	–	0.6	I.0	– 0,6	– 0.3	– 0.5	– 2.I	– I.3
6.5	0,0	0.0	–	0.2	– 0.2	0,5	– 0.I	– I.2	– 0.I	0.8
6.6	– 0,4	0.2	– 0.8	– 2.2	0.3	– 0,6	0.4	–	– 0.2	I.0

Supplement 1.

Tables of magnetic element values of the stations utilized with the completion of world isoperiodic charts for 1960 - 1965.

No. Station Per.
Name

№№ п/п	Название обсерваторий	Период	φ	λ	δD	δI	δH	δZ	δX	δY	δT
I	2	3	4	5	6	7	8	9	I0	II	I2
I.	Алерт	I962-64	82°.5 С	297°.5 В	+ 06'.–	+0I'.0	-I5γ	+26γ	+ 4γ	+I6γ	+24γ
2.	Хейса	I960-63	80°37'	58°.03'	+ 02.–	+00.8	- 9	+46	-I0	- 2	+44
3.	Челюскин	I960-65	77 43	I04.I7	- 20.–	-00.2	+ 6	+42	+I3	-I6	+40
4.	Туле	I960-63	76 32	29I 06	+ I0.–	+08.0	-I0	+39	+ 9	+I3	+38
5.	Моулд Бей	I962-64	76.2	240.6	- I8.–	-00.6	+I0	0	+I6	+ 4	0
6.	Резольют Бей	I960-64	74 4I	265 05	+I°I0.2	+00.6	-I0	+23	+I2	+I2	+29
7.	Медвежий	I960-65	74 30	I9 00	+ 02.3	0	+ 5	+3I	+ 5	+ 6	+32
8.	Диксон	I960-65	73 33	80 34	- 08.7	0	+ 3	+26	+II	-I2	+30
9.	Тикси	I960-64	7I 35	I29 00	- 02.7	-02.0	+35	+I4	+32	-I5	+I9
I0.	Барроу	I960-65	7I I8	203 I5	- 02.0	-0I.I	+26	-I6	+28	+ I	+I4
II.	Тромсе	I960-65	69 40	I8 57	+ 0I.0	-00.4	+II	+23	+II	+ 4	+27
I2.	Годхавн	I960-63	69 I4	306 29	+ 07.8	-00.2	+ 7	+36	+I6	+ 6	+37
I3.	Мурманск (Лопарское)	I960-64	68 I5	33 05	+ 00.I	+00.2	+ 2	+27	+ 2	+ I	+26
I4.	Соданкюля	I960-64	67 22	26 39	+ 0I.4	-00.6	+I5	+22	+I4	+ 6	+25
I5.	Уэлен	I960-65	66 I0	I90 I0	- 0I.7	-0I.4	+25	+ 3	+25	0	+ 9
I6.	Колледж	I960-65	64 52	2I2 I0	- 02.9	-0I.4	+2I	- 9	+24	+ I	- 4
I7.	Бейкер Лейк	I960-64	64 I8	263 55	+ 05.5	-0I.6	+27	- 2	+29	+ 8	+ I
I8.	Рейкъявик	I960-65	64 II	338 I8	+ 05.2	-0I.5	+29	+25	+34	+ 5	+3I
I9.	Среднекан	I960-64	62 26	I52 I9	+ 00.5	-0I.6	+27	- 2	+27	- 3	+ 6
20.	Домбос	I960-64	62 05	09 06	+ 03.6	-00.9	+20	+22	+2I	+I3	+26
2I.	Якутск	I960-65	62 0I	I29 43	- 00.7	-02.0	+3I	-I3	+32	-I6	- 4
22.	Нурми-Ярви	I960-65	60 30	24 39	+ 0I.3	-00.5	+I4	+2I	+I4	+ 7	+24
23.	Леруик	I960-63	60 08	358 49	+ 05.0	-0I.3	+24	+I8	+27	+I6	+24
24.	Ленинград (Воейково)	I960-65	59 57	30 42	+ 0I.3	-00.4	+I4	+23	+I3	+ 7	+26
25.	Ловё	I960-63	59 2I	I7 50	+ 02.9	-00.5	+I6	+24	+I6	+I2	+28
26.	Ситка	I960-65	57 04	224 40	- 03.3	-0I.4	+I8	-I9	+23	- 4	-I3
27.	Свердловск (Выс.Дубрава)	I960-65	56 44	6I 04	- 0I.9	-00.5	+I4	+I6	+I6	- 5	+I9
28.	Руде-Сков	I960-65	55 5I	I2 27	+ 03.5	-00.7	+I8	+I9	+I8	+I7	+24
29.	Казань (Займище)	I960-64	55 50	48 5I	- 00.7	-00.4	+I2	+I7	+I2	- 2	+I9
30.	Москва (Красная Пахра	I960-65	55 28	37 I9	0	-00.3	+II	+I7	+II	+ 2	+2I
3I.	Эскдейльмьюр	I960-63	55 I9	356 48	+ 05.4		+30	+I4	+36	+20	+24
32.	Минук	I960-65	54 37	246 40	- 03.6	-0I.9	+29	-20	+32	- I	-I3
33.	Минск (Плещеницы)	I96I-65	54 30	27 53	+ 00.8	-00.2	+II	+20	+II	+ 6	+22
34.	Вингст	I960-65	53 45	09 04	+ 04.I	-0I.0	+20	+I5	+22	+20	+22
35.	Виттевен	I960-65	52 49	06 40	+ 04.4	-0I.0	+22	+I5	+23	+22	+22
36.	Иркутск (Патроны)	I960-65	52 I0	I04 27	- 02.9	-0I.6	+24	-I5	+23	-I8	+ 7
37.	Свидер	I960-63	52 07	2I I5	+ 02.6	-00.3	+I3	+20	+I3	+I4	+24

Station
Name Period

№№ п/п	Название обсерваторий	Период	φ	λ	δD	δI	δH	δZ	δX	δУ	δT
I	2	3	4	5	6	7	8	9	I0	II	I2
38.	Нимег	I960-65	52 04	I2 40	+ 03.6	-00.7	+I8	+I8	+I9	+I9	+24
39.	Валенсия	I960-65	5I 56	349 45	+ 06.I	-02.3	+38	+ 8	+44	+23	+22
40.	Абинджер	I960-64	5I II	359 37	+ 05.9	-02.0	+33	+ 8	+38	+26	+20
4I.	Киев	I960-64	50 43	30 I8	+ 0I.4	0	+II	+25	+I0	+ 8	+26
42.	Дурб	I960-65	50 06	4 36	+ 04.9	-0I.3	+26	+I3	+28	+25	+23
43.	Пругонице	I960-64	49 59	I4 33	+ 03.7	-00.3	+I5	+23	+I6	+2I	+28
44.	Львов	I960-65	49 54	23 45	+ 0I.8	-00.6	+I5	+I4	+I4	+II	+I9
45.	Виктория	I960-64	48 3I	236 35	- 02.9	-0I.9	+22	-3I	+27	- 6	-22
46.	Вена-Кобенцл	I960-65	48 I6	I6 I9	+ 03.2	-00.6	+I7	+I8	+I7	+I9	+23
47.	Фюрстен-Фельдбрюк	I960-65	48 I0	II I7	+ 04.2	-00.8	+20	+I6	+2I	+25	+23
48.	Шамбон-ла-Форе	I960-65	48 0I	02 I6	+ 05.3	-0I.7	+29	+ 7	+33	+28	+I9
49.	Гурбаново	I960-64	47 54	I8 I2	± 03.I	-00.5	+I9	+22	+I9	+I9	+28
50.	Регенсбург	I960-63	47 29	08 27	+ 04.8	-0I.2	+26	+I4	+27	+27	+23
5I.	Ю.Сахалинск	I960-65	46 57	I42 43	+ 00.3	-02.I	+I8	-3I	+I8	- I	-I8
52.	Тихань	I960-64	46 54	I7 54	+ 03.2	-00.3	+I6	+22	+I7	+20	+28
53.	Одесса	I960-65	46 47	30 53	+ 00.7	0	+I0	+2I	+I0	+ 5	+23
54.	Сурларь	I960-65	44 4I	26 I5	+ 02.I	-00.2	+I0	+25	+I0	+I5	+3I
55.	Гроцка	I960-65	44 38	20 46	+ 02.6	-00.I	+I4	+22	+I4	+I7	+26
56.	Мемамбецу	I960-63	43 55	I44 I2	+ 00.3	-0I.I	+ 9	-24	+I2	+ I	-I5
57.	Аженкорт	I960-64	43 47	280 44	- 02.0	-04.0	+6I	-30	+59	-I7	-I3
58.	Владивосток (Горнотаёжная)	I960-64	43 4I	I32 I0	- 00.2	-0I.3	+I6	-I4	+I5	- 4	- 4
59.	Алма-Ата	I963-65	43 I5	76 55	-	-0I.2	+20	0	+I8		+ 9
60.	Панагюрище	I960-65	42 30	24 I0	+0I.9	+00.I	+I6	+28	+I5	+I4	+32
6I.	Логроньо	I960-65	42 27	359 04	+06.2	-02.6	+38	- 4	+43	+37	+I7
62.	Сан-Витто-рино	I960-64	42 24	I3 I9	+ 04.I	-00.5	+2I	+22	+22	+28	+30
63.	Тбилиси (Душети)	I960-65	42 05	44 42	- 0I.2	-00.I	+II	+I5	+II	- 7	+I8
64.	Ташкент (Янги-Базар)	I960-65	4I 20	69 37	- 0I.3	-0I.0	+I8	+ 2	+I9	- 8	+II
65.	Кандилли	I960-63	4I 04	29 04	+ 00.8	+00.I	+I0	+23	+ 7	+ 7	+26
66.	Тортоза	I960-65	40 49	0 3I	+ 06.2		+34		+39	+ 40	
67.	Коимбра	I960-65	40 I3	35I 35	+ 06.5	-03.4	+4I	-I6	+49	+38	+I0
68.	Толедо	960-65	39 53	355 57	+ 06.6	-03.I	+4I	-II	+48	+4I	+I4
69.	Фредерикс-берг	I960-65	38 I2	282 38	- 04.2	-04.9	+65	-58	+62	-3I	-32
70.	Сан-Мигель	I960-64	37 46	334 2I	+ 07.8	-06.8	+73	-54	+86	+35	- 6
7I.	Ашхабад (Ванновская)	I960-65	37 57	58 06	- 0I.7	-0I.6	+I4	+ 3	+I5	-I2	+ 9
72.	Альмерия	I960-65	36 5I	357 33	+ 06.4	-03.0	+40	- 9	+45	+44	+I7
73.	Сан-Фернан-до	I960-65	36 28	353 48	+ 07.9		+44		+52	+53	
74.	Какиока	I960-64	36 I4	I40 II	+ 00.I	-0I.7	+I3	- 26	+ 7	0	-I4
75.	Симосато	I960-65	33 35	I35 56	- 00.3	-0I.8	+II	- 23	+II	- 4	- 9
76.	Таксон	I960-65	32 I5	249 I0	- 0I.9	-0I.I	- 6	- 44	- 3	-I6	-42

No. Station Period
Name

№№ п/п	Название обсерваторий	Период	φ	λ	δD	δI	δH	δZ	δX	δY	δT
	2	3	4	5	6	7	8	9	I0	II	I2
77.	Каноя	I960-63	3I 25	I30 53	-00.8	-0I.6	+ I4	- 24	+ 9	- 9	- 9
78.	Кветта	I960-62	30 II	66 57	-0I.3	-	+ 22	-	+ 22	- I4	
79.	Мисахат	I960-65	29 3I	30 54	+0I.3	+00.I	+ 20	+ 2I	+ 20	+ I2	+ 29
80.	Санта Круз	I960-65	28 28	343 45	+07.8	-08.2	+ 58	-70	+ 70	+ 52	- 4
8I.	Ша-па	I960-63	22 2I	I03 50	-00.3	-0I.3	+ 4	-I7	+ 4	- 9	- 5
82.	Гонолулу	I960-65	2I I8	20I 54	+00.I	-00.2	- I2	-I3	- I2	- 2	- I7
83.	Теолоюкан	I960-65	I9 45	260 49	-03.8	-00.4	- 37	-47	- 3I	- 39	- 59
84.	Алибаг	I960-64	I8 38	72 52	-0I.0	-02.4	+ 32	-I8	+ 32	- 9	+ 22
85.	Сан-Хуан	I960-65	I8 23	293 53	-06.5	-07.4	+ 7	- I42	- I	- 52	-I06
86.	М'Бур	I960-65	I4 24	343 02	+07.5	-I2.6	+ I9	- I2I	+ 35	+ 52	- I6
87.	Мунтинлупа	I960-64	I4 22	I2I 0I	-02.2	-0I.8	+ 20	- I6	+ 20	- 22	+ I5
88.	Гуам	I960-65	I3 27	I44 45	+00.7	-03.8	+ I0	- 39	+ I0	+ 7	+ 2
89.	Аннамалай-нагар	I960-65	II 24	79 4I	+00.3		+ I7		+ I7	+ 3	
90.	Кодайканал	I960-64	I0 I4	77 28	-00.8	-03.2	+ 8	- 37	+ 7	- 5	+ 5
9I.	Адис-Абеба	I959-64	9 02	38 46	-03.8	-00.2	+ I9	- 3	+ I9	- 39	+ I8
92.	Тривандрум	I960-65	8 29	76 57	+00.3	-02.6	+ I0	- 30	+ 9	+ 3	+ I0
93.	Парамарибо	I960-65	5 48	304 47	-07.7	-I0.4	- 27	-I39	- 4I	- 58	- 97
94.	Фукэне	I960-65	5 28	286 I6	-07.6	-02.5	- 56	- 67	- 55	- 67	- 84
95.	Банги	I960-62	4 26	I8 34	+03.6	-04.0	+ I0	- 40	+ I4	+ 32	+ 20
96.	Мока	I960-65	3 2I	8 40	+04.3	-04.6	+ 2	- 43	+ 8	+ 38	+ I5
97.	Татуока	I960-65	I I2	3II 29	-07.4	-I5.3	- 35	-I48	- 5I	- 50	- 75
98.	Львиро	I960-65	2.2	28.8	+03.5	-03.7	- II	- 36	- 9	+ 3I	+ 8
99.	Голландия	I960-62	2 35	I40 3I	+ 0.8	-02.5		- 39		+ I2	+ I8
I00.	Кейпер	I960-62	6 02	I06 44	-02.4	-0I.8	+ I6	- 40	+ I5	- I5	+ 32
I0I.	Луанда	I960-64	8 55	I3 I0	+03.0	-07.2	- 34	- 52	- 38	+ 29	+ 3
I02.	Морсби	I960-65	9 24	I47 09	+0I.3	-03.0	- I9	- 33	- 20	+ I4	+ 2
I03.	Апиа	I960-65	I3 48	I88 I4	+02.2	+00.3	- I0	+ I0	- I5	+ I9	- I4
I04.	Тананариве	I960-65	I8 55	47 32	-06.2	-00.2	- I9	+ 24	- 26	-32	- 32
I05.	Маврикия	I960-63	20 06	57 33	-04.5	-0I.3	- I6	+ 2	- 24	-23	- I2
I06.	Ла-Кьяка	I96I-65	22 06	294 25	-09.4	-00.9	- 62	+ 9	- 6I	-68	- 62
I07.	Васорас	I960-65	22 24	3I6 2I	-09.3	-I2.7	- 59	- 73	- 74	-4I	- 25
I08.	Гнангара	I960-65	30 I9	II5 53	+00.4	-00.6	- II	- 3	- I0	+ 3	- I
I09.	Пилар	I960-65	3I 40	296 07	-08.5	-0I.9	- 62	+ I7	- 60	-59	- 63
II0.	Херманюс	I960-65	34 25	I9 I4	-0I.3	-02.5	- 7I	+I00	- 66	+25	-I2I
III.	Туданги	I960-65	37 32	I45 28	+03.I	-0I.0	- 23	+ 3	- 26	+I6	- I4
II2.	Амберли	I960-65	43 I0	I72 43	+05.2	-00.2	- I6	+ 34	- 27	+26	- 37
II3.	Трелью	I960-64	43 I4	294 42	-06.5	-02.3	- 77	+ 38	- 70	-54	- 84
II4.	Порт-о-Франсе	I960-63	49 2I	70 I5	-I3.2	-0I.2	- 4	- 46	- 57	-45	+ 40
II5.	Маккуори	I960-65	54 30	I58 57	+I0.I	-00.7	- 2I	+ 38	- 37	+25	- 44
II6.	Аргентинские острова	I960-64	65 I5	295 I4	-07.I	-00.7	- 37	+I09	- 33	-20	- 97

№№ п/п	Название обсерватор.		φ	λ	δD	δI	δH	δZ	δX	δY	δT
1	2	3	4	5	6	7	8	9	10	11	12
117.	Уилкс	1960-65	66 15	110 21	- 26.7	+00.4	- 9	+ 56	- 72	+ 3	- 57
118.	Мирный	1960-65	66 33	93 01	- 19.8	+00.4	+ 2	+ 68	- 78	- 13	- 68
119.	Дюмон-д-Юрвиль	1960-63	66 40	140 01		0	+ 2	+ 24	- 41	+ 18	- 24
120.	Маусон	1960-65	67 36	62 54	- 14.6	+02.4	+ 7	+ 87	- 65	- 44	- 79
121.	Сёва	1960-62	69 02	39 36	- 08.0		+ 18	+126	- 20	- 45	
122.	Новолазаревская	1961-64	70 46	11 50	-04.0	+04.3	- 5	+139	- 15	- 17	-130
123.	База Скотта	1958-65	77 51	166 47	-04.0	+03.0	+ 56	- 90	- 40	+ 45	- 75
124.	Восток	1960-64	78 27	106 52	-17.0	+03.0	+ 34	+120	- 70	- 2	-112
125.	Берд	1960-64	79 59	240 00	+00.7	+03.0	+ 21	+123	+ 4	+ 21	-108
126.	Южный полюс	1960-64	90 00	200 00	-04.7	+03.1	+ 20	+123	+ 10	- 25	-113

Supplement II.

Table of

Average annual changes of magnetic declination (δD) for the 1960 - 1965 period. (min/year)

φ \ λ	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
90	-10.0																	
80	4.0	3.5	3.0	2.5	2.5	2.0	0.0	-6.0	-10.0	-16.0	-24.0	-25.0	-24.0	-20.0	-15.0	-10.0	-10.0	-12.0
70	4.0	3.0	2.0	1.0	1.0	0.0	-2.0	-5.0	-8.0	-10.0	-9.0	-7.0	-5.5	-4.0	-3.0	-1.5	-1.5	-1.5
60	5.0	4.0	2.0	1.0	0.0	-1.0	-2.0	-3.5	-5.0	-5.5	-5.0	-3.5	-2.0	-1.5	0.0	0.0	0.0	0.0
50	5.5	4.5	2.5	1.0	0.0	-1.0	-2.0	-2.0	-3.0	-3.0	-3.0	-2.0	-1.5	-1.0	0.0	0.0	0.5	0.5
40	6.0	5.0	3.0	1.0	0.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	0.0	0.0	0.5	0.5
30	6.0	5.0	3.5	1.5	-0.5	-1.0	-1.5	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	0.0	0.0	0.5	0.5
20	6.0	5.0	3.5	1.5	-1.0	-2.0	-1.0	-1.0	-0.5	0.0	-0.5	-1.5	-1.5	-1.0	0.0	0.5	1.0	1.0
10	6.0	4.5	3.0	1.0	-2.5	-3.0	-2.0	-0.5	0.0	0.0	-1.5	-2.0	-2.0	-1.0	0.0	1.0	1.0	1.5
0	4.5	4.0	3.0	0.5	-3.5	-4.0	-3.0	-1.5	-1.0	-1.5	-2.0	-2.5	-1.5	0.0	0.5	1.0	1.5	1.5
-10	2.5	2.5	2.0	0.0	-4.0	-4.5	-4.0	-3.0	-3.0	-2.5	-2.5	-2.0	0.0	0.5	1.0	1.5	2.0	2.0
-20	0.5	1.0	0.5	-1.0	-4.0	-4.5	-5.0	-5.0	-4.5	-4.0	-3.0	-1.0	0.5	1.0	1.5	2.0	2.5	2.5
-30	-1.0	-0.5	-1.0	-2.0	-4.0	-5.0	-6.0	-7.0	-6.5	-5.5	-3.5	-1.0	0.5	1.5	2.0	3.0	3.5	3.5
-40	-2.5	-1.5	-2.0	-3.0	-5.0	-6.0	-8.0	-9.0	-9.0	-8.0	-6.0	-2.0	0.5	1.5	2.5	3.5	4.5	5.0
-50	-3.0	-2.5	-3.0	-4.0	-6.0	-8.0	-11.0	-12.0	-12.0	-12.0	-9.5	-6.0	-1.5	1.0	3.0	5.0	8.0	8.0
-60	-3.5	-3.5	-3.5	-5.0	-7.5	-10.0	-13.0	-15.0	-16.0	-17.0	-16.0	-13.0	-8.0	-1.0	3.0	9.0	20.0	10.0
-70	-4.0	-4.0	-5.0	-6.5	-8.0	-11.0	-14.0	-16.0	-17.0	-19.0	-24.0	-28.0	-30.0	-30.0	-8.0	-2.0	1.0	1.5
-80	-7.0	-7.0	-7.0	-7.5	-8.0	-9.0	-10.0	-12.0	-13.0	-14.0	-14.0	-13.0	-12.0	-10.0	-7.0	-5.5	-4.5	-3.0
-90	-5.5																	

φ \ λ	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
90																		
80	-15.0	-16.0	-20.0	-20.0	-25	-30	-32	-30	-10	10	15	12	9.0	7.5	6.5	6.0	5.0	5.0
70	-1.5	-2.0	-2.0	-4.0	-8.0	-10	-12	-8.0	2.0	25	25	15	9.0	8.0	7.0	6.5	6.0	5.0
60	0.0	-0.5	-1.0	-2.0	-3.0	-5.0	-5.0	-3.0	2.0	8.0	10	10	9.0	8.0	7.5	7.5	6.5	5.5
50	0.0	0.0	-1.0	-1.5	-2.0	-3.0	-3.0	-2.0	-2.0	-0.5	2.0	4.0	5.5	6.5	7.0	7.5	7.0	6.0
40	0.5	0.0	-0.5	-1.0	-2.0	-2.0	-2.5	-2.5	-3.0	-3.0	-2.5	0.0	2.0	5.0	6.0	7.0	7.0	6.5
30	0.5	0.5	0.0	-0.5	-1.5	-2.0	-2.5	-3.0	-3.5	-4.0	-4.5	-4.5	-1.0	2.0	5.0	6.0	6.5	6.5
20	1.0	0.5	0.5	-0.5	-1.5	-2.5	-3.0	-3.0	-4.0	-4.5	-6.0	-6.0	-6.0	-1.0	2.0	5.0	6.0	6.5
10	1.5	1.0	0.5	0.0	-1.0	-2.0	-3.0	-3.5	-4.0	-5.5	-7.0	-7.5	-7.0	-6.0	0.0	3.0	5.5	6.0
0	1.5	1.5	1.0	0.0	-0.5	-2.0	-2.5	-3.5	-4.5	-6.0	-7.5	-8.0	-8.0	-7.0	-5.0	0.0	2.5	4.0
-10	2.0	2.0	1.5	0.5	-0.5	-1.5	-2.5	-3.5	-4.5	-6.0	-8.0	-9.0	-9.5	-9.0	-7.0	-4.0	0.0	1.5
-20	2.5	2.0	1.5	1.0	0.0	-1.0	-2.0	-3.0	-4.5	-6.0	-7.5	-9.0	-10	-9.5	-8.5	-6.0	-3.0	-1.0
-30	3.5	3.0	2.0	1.0	0.0	-1.0	-2.0	-3.0	-4.5	-5.5	-7.0	-8.0	-8.5	-8.5	-8.0	-6.0	-4.5	-2.5
-40	4.5	3.5	2.5	1.5	0.5	-0.5	-2.0	-3.0	-4.0	-5.0	-6.0	-7.5	-8.0	-8.0	-7.5	-6.0	-5.0	-3.5
-50	5.5	4.0	3.0	2.0	1.0	-0.5	-2.0	-3.0	-4.0	-5.0	-5.5	-6.5	-7.5	-7.5	-7.5	-6.0	-5.0	-4.0
-60	7.0	4.0	3.0	1.5	1.0	0.0	-1.0	-2.5	-3.5	-4.5	-5.0	-6.0	-6.5	-7.0	-6.5	-6.0	-5.0	-4.0
-70	1.5	1.5	1.5	1.5	1.0	0.5	0.0	-1.0	-3.0	-4.0	-5.0	-6.0	-6.0	-7.0	-6.5	-6.0	-5.5	-5.0
-80	-2.0	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.0	-3.0	-4.0	-5.0	-6.0	-6.0	-6.5	-6.5	-6.5	-6.5
-90																		

Minus--east declination diminishes, west declination grows.

Plus--east declination grows, west declination diminishes.

Table of

average annual changes of magnetic inclination (δI) for the 1960 - 1965 period (min/year)

φ \ λ	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
90	0.2																	
80	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.1	0.0	-0.2	-0.4	-0.5	-0.6	-0.6	-0.6	-0.6
70	- 0.2	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0	-0.2	-0.4	-0.6	-1.0	-1.1	-1.2	-1.2	-1.2	-1.2	-1.3
60	-1.2	-0.8	-0.5	-0.5	-0.5	-0.5	-0.4	-0.5	-0.6	-0.8	-1.1	-1.2	-1.3	-1.4	-1.4	-1.4	-1.4	-1.2
50	-1.7	-1.0	-0.5	-0.1	-0.2	-0.4	-0.6	-0.7	-0.9	-1.2	-1.3	-1.4	-1.5	-1.6	-1.6	-1.6	-1.5	-1.4
40	-2.2	-1.2	-0.4	0.0	-0.1	-0.5	-0.7	-1.1	-1.2	-1.3	-1.5	-1.6	-1.7	-1.8	-1.8	-1.8	-1.8	-1.5
30	-3.6	-1.6	-0.6	0.0	-0.2	-0.6	-1.0	-1.2	-1.4	-1.6	-1.7	-1.8	-1.8	-2.0	-2.2	-2.2	-2.0	-1.6
20	-5.4	-2.9	-1.2	-0.6	-0.5	-0.7	-1.1	-1.4	-1.6	-1.8	-1.9	-2.0	-2.4	-2.7	-2.8	-2.9	-2.5	-1.9
10	-7.2	-4.4	-2.6	-1.4	-0.9	-1.0	-1.3	-1.7	-2.0	-2.2	-2.4	-2.7	-3.0	-3.4	-3.5	-3.2	-2.6	-1.9
0	-8.0	-5.6	-3.6	-2.4	-1.6	-1.4	-1.5	-1.8	-2.1	-2.3	-2.5	-2.7	-3.0	-3.0	-3.0	-2.8	-2.3	-1.6
-10	-7.9	-5.8	-4.0	-2.7	-1.8	-1.6	-1.6	-1.9	-2.1	-2.4	-2.5	-2.4	-2.3	-2.0	-2.0	-2.0	-1.8	-1.2
-20	-7.0	-5.4	-3.8	-2.6	-1.8	-1.5	-1.6	-1.9	-2.1	-2.2	-2.2	-2.0	-1.8	-1.7	-1.6	-1.5	-1.2	-0.8
-30	-5.6	-4.4	-3.0	-2.0	-1.5	-1.4	-1.5	-1.7	-2.0	-2.0	-1.8	-1.7	-1.5	-1.3	-1.2	-1.0	-0.8	-0.6
-40	-4.7	-2.6	-1.4	-0.7	-0.6	-0.8	-1.1	-1.3	-1.4	-1.4	-1.3	-1.2	-1.1	-1.0	-0.9	-0.8	-0.6	-0.4
-50	-0.8	0.0	0.8	1.0	0.9	0.4	0.0	-0.3	-0.5	-0.6	0.7	-0.7	-0.8	-0.7	-0.6	-0.5	-0.4	-0.2
-60	1.7	2.0	2.0	2.0	2.0	1.8	1.4	1.0	0.6	0.2	0.0	-0.2	-0.2	-0.3	-0.3	-0.2	-0.1	-0.1
-70	3.0	3.4	3.4	3.0	3.0	2.6	2.3	2.0	1.6	1.2	0.7	0.6	0.4	0.3	0.2	0.2	0.4	0.4
-80	2.7	2.7	2.7	2.7	2.6	2.5	2.4	2.2	2.1	2.0	1.7	1.5	1.2	1.0	1.0	1.0	1.0	1.1
-90	2.0																	

φ \ λ	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
90																		
80	-0.6	-0.6	-0.5	-0.4	-0.2	-0.1	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
70	-1.3	-1.3	-1.2	-1.2	-1.0	-1.0	-0.8	-0.7	-0.6	-0.5	-0.5	-0.5	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3
60	-1.2	-1.0	-0.9	-1.0	-1.3	-1.4	-1.5	-1.5	-1.5	-1.6	-1.6	-1.6	-1.5	-1.4	-1.4	-1.4	-1.4	-1.4
50	-1.1	-0.9	-0.7	-0.7	-1.0	-1.2	-1.4	-1.6	-2.0	-2.4	-2.6	-2.7	-2.7	-2.9	-3.0	-3.0	-2.9	-2.4
40	-1.0	-0.8	-0.5	-0.5	-0.7	-0.8	-1.1	-1.5	-2.0	-2.5	-3.2	-3.5	-3.9	-4.4	-4.8	-4.8	-4.4	-3.6
30	-1.0	-0.6	-0.4	-0.4	-0.5	-0.6	-0.8	-1.2	-1.7	-2.3	-3.2	-4.0	-5.2	-6.2	-6.6	-6.8	-6.6	-5.5
20	-1.0	-0.6	-0.2	-0.3	-0.4	-0.5	-0.7	-1.1	-1.6	-2.0	-3.2	-5.0	-6.6	-7.8	-9.0	-9.2	-9.0	-7.6
10	-1.0	-0.5	-0.2	-0.1	-0.2	-0.3	-0.6	-1.0	-1.4	-1.8	-3.1	-5.2	-8.0	-10.0	-12.0	-12.2	-12.0	-10.0
0	-0.8	-0.4	0.0	0.1	0.1	0.0	-0.3	-0.7	-1.2	-1.7	-3.0	-5.2	-9.0	-12.0	-14.0	-14.3	-13.1	-11.0
-10	-0.7	-0.2	0.2	0.2	0.2	0.2	0.0	- 0.2	-0.8	-1.5	-2.6	-5.0	-8.5	-12.4	-14.3	-14.6	-12.6	-10.2
-20	-0.6	0.0	0.2	0.4	0.5	0.6	0.6	0.5	0.2	-1.0	- 2.2	-4.0	-7.2	-10.0	-13.0	-12.4	-10.8	- 9.0
-30	-0.3	0.1	0.4	0.5	0.6	0.8	1.2	1.2	1.1	0.0	-1.6	-3.4	-5.4	- 7.4	- 8.9	- 9.1	- 8.2	- 7.0
-40	-0.2	0.2	0.5	0.6	0.8	0.8	1.4	1.7	1.7	1.2	-0.4	-2.0	- 3.8	- 5.2	- 6.0	- 6.0	- 5.9	- 5.0
-50	0.0	0.2	0.6	0.7	0.8	0.8	1.5	2.0	2.4	2.0	1.2	0.4	-0.5	- 1.0	- 1.6	- 1.8	- 2.0	- 1.6
-60	0.2	0.5	0.7	1.0	1.2	1.2	1.6	1.8	1.8	1.6	1.6	1.6	1.5	1.4	1.3	1.5	1.4	1.5
-70	0.6	0.8	1.0	1.2	1.3	1.3	1.4	1.5	1.6	1.9	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.9
-80	1.2	1.2	1.4	1.5	1.5	1.5	1.8	1.8	2.0	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.6	2.6
-90																		

Table of

average annual changes of horizontal composition (δH) for the 1960 - 1965 period.
(γ/year).

φ \ λ	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
90	-17																																			
80	-7	-5	-6	-6	-6	-6	-6	-5	-2	0	2	5	7	10	10	12	14	12	12	12	12	10	8	4	0	-10	-20	-22	-20	-17	-15	-12	-10	-9	-8	-7
70	10	9	8	8	6	4	4	6	6	9	12	18	25	31	33	32	30	26	25	25	25	24	22	21	21	22	22	20	10	5	4	5	6	8	8	9
60	24	21	17	13	12	11	11	12	14	17	21	24	28	29	27	25	22	20	18	16	16	16	20	23	26	30	32	32	32	31	30	27	27	26	26	25
50	32	23	18	15	14	14	15	16	18	22	25	23	21	20	18	16	14	11	9	6	6	7	10	17	23	29	35	40	44	46	46	46	45	44	40	36
40	37	25	19	18	16	16	17	19	22	25	20	18	16	14	12	9	7	4	1	-1	-2	-2	-2	0	6	18	29	40	60	62	64	66	68	69	60	47
30	34	26	23	20	20	20	20	23	24	20	17	15	13	11	8	5	2	-2	-4	-5	-8	-9	-10	-11	-12	-10	-4	10	25	40	46	50	53	55	55	45
20	26	24	24	25	25	26	24	23	21	17	14	12	10	7	4	2	-2	-5	-7	-9	-12	-13	-15	-16	-19	-22	-23	-18	-5	5	12	18	24	28	30	30
10	12	14	16	18	20	19	18	17	15	12	11	9	7	4	2	-1	-5	-9	-11	-12	-14	-15	-16	-19	-24	-30	-36	-41	-40	-20	-12	-8	-4	0	6	10
0	-8	-7	-5	-5	-4	-2	2	5	6	6	6	5	4	2	0	-7	-11	-12	-12	-12	-15	-16	-18	-22	-28	-34	-40	-50	-50	-46	-40	-30	-24	-18	-14	-10
-10	-36	-30	-28	-22	-16	-10	-6	-4	-2	2	2	2	0	-4	-10	-14	-15	-14	-13	-15	-15	-17	-18	-21	-28	-34	-40	-48	-52	-52	-51	-50	-45	-42	-40	-36
-20	-60	-55	-50	-40	-30	-18	-13	-8	-6	-4	-3	-3	-5	-12	-19	-20	-18	-16	-17	-15	-15	-17	-18	-20	-26	-33	-40	-49	-55	-58	-62	-62	-62	-62	-62	-60
-30	-70	-70	-66	-54	-39	-22	-16	-11	-8	-6	-6	-8	-12	-18	-22	-22	-20	-17	-17	-15	-15	-16	-17	-19	-25	-32	-39	-50	-58	-64	-68	-70	-70	-72	-72	-70
-40	-74	-72	-68	-57	-40	-25	-16	-10	-6	-7	-8	-10	-15	-20	-22	-23	-21	-17	-16	-15	-14	-14	-15	-18	-23	-30	-38	-47	-60	-66	-72	-74	-76	-78	-78	-76
-50	-66	-63	-55	-44	-30	-19	-11	-5	-4	-5	-7	-9	-14	-19	-22	-24	-21	-16	-13	-11	-9	-10	-12	-16	-19	-25	-32	-40	-50	-59	-64	-68	-70	-70	-70	-69
-60	-48	-42	-35	-21	-12	-3	3	4	2	-2	-4	-6	-10	-17	-21	-21	-18	-12	-7	-2	0	-3	-6	-10	-15	-19	-24	-31	-38	-44	-48	-50	-50	-50	-50	-50
-70	-16	-12	-4	4	10	16	16	14	13	10	10	9	9	12	22	20	18	17	15	15	13	11	6	0	-5	-9	-13	-15	-20	-20	-22	-22	-22	-22	-20	-20
-80	6	10	13	18	22	24	26	30	32	32	34	36	38	42	45	50	48	44	41	36	32	28	24	22	20	12	7	4	2	1	0	0	0	2	3	4
-90	24																																			

Table of

average annual changes of northern composition (δX) for the 1960 - 1965 period. (X/year).

φ \ λ	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
90	0																	
80	2	0	-3	-4	-6	-7	-10	-6	-2	2	7	10	12	15	17	18	20	20
70	16	13	11	6	4	4	6	10	12	15	17	22	28	32	33	31	30	28
60	26	18	16	12	9	11	12	15	17	18	22	27	30	30	26	23	21	20
50	35	23	18	16	14	14	15	17	18	21	25	26	24	20	18	16	14	12
40	42	30	20	18	16	16	17	18	21	24	24	21	17	16	14	11	9	7
30	40	32	26	20	17	16	18	21	22	22	20	16	14	12	9	7	5	4
20	33	28	22	17	16	15	20	21	21	18	16	13	11	8	6	4	2	1
10	17	16	14	13	13	13	15	16	16	14	12	10	7	5	3	1	-3	-5
0	-5	-4	-2	-1	0	0	0	4	8	8	8	6	5	2	0	-7	-10	-12
-10	-30	-29	-26	-20	-18	-12	-10	-8	-4	1	3	3	2	0	-8	-16	-19	-17
-20	-60	-53	-48	-42	-34	-28	-22	-19	-14	-10	-4	-1	-3	-8	-18	-22	-22	-21
-30	-65	-63	-62	-60	-50	-44	-38	-30	-26	-22	-18	-14	-14	-16	-21	-24	-25	-24
-40	-67	-65	-63	-61	-56	-50	-50	-44	-38	-34	-30	-25	-22	-22	-25	-27	-28	-27
-50	-62	-60	-58	-54	-51	-52	-55	-56	-55	-49	-40	-37	-32	-31	-32	-32	-32	-31
-60	-40	-39	-38	-38	-38	-50	-60	-65	-67	-66	-62	-56	-46	-39	-38	-37	-36	-32
-70	-14	-14	-17	-18	-20	-33	-50	-64	-70	-76	-78	-75	-68	-61	-52	-40	-36	-32
-80	4	0	-5	-10	-15	-22	-30	-40	-50	-60	-65	-65	-64	-60	-55	-50	-42	-36
-90																		

φ \ λ	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
90																		
80	19	18	17	16	15	13	12	11	9	7	7	6	6	6	5	5	5	4
70	27	27	26	25	24	24	22	20	18	18	16	16	16	17	18	20	20	18
60	19	20	20	22	25	30	32	33	33	32	36	40	40	40	38	37	36	32
50	12	11	13	15	18	22	26	30	35	40	50	56	57	58	58	56	51	45
40	6	6	6	6	8	10	12	20	26	38	56	65	72	78	80	82	74	55
30	2	2	0	-1	-2	-3	-4	-4	-2	6	22	40	50	60	64	70	68	54
20	-2	-3	-4	-5	-7	-10	-12	-13	-14	-12	-8	6	20	30	40	42	44	40
10	-6	-6	-7	-10	-10	-15	-17	-20	-24	-25	-25	-25	-20	-10	6	15	20	20
0	-11	-9	-10	-10	-14	-17	-22	-27	-30	-35	-39	-42	-44	-40	-32	-20	-10	-8
-10	-15	-14	-10	-10	-15	-19	-25	-30	-34	-38	-46	-52	-58	-60	-60	-51	-40	-35
-20	-19	-17	-14	-10	-15	-20	-25	-30	-35	-40	-50	-58	-66	-70	-78	-66	-64	-62
-30	-22	-20	-17	-12	-14	-19	-24	-29	-34	-40	-52	-62	-70	-75	-80	-76	-72	-70
-40	-25	-22	-20	-13	-13	-17	-22	-27	-33	-38	-51	-62	-70	-70	-72	-72	-71	-70
-50	-27	-24	-20	-14	-10	-14	-17	-22	-28	-35	-44	-54	-60	-62	-62	-63	-63	-62
-60	-27	-22	-18	-12	-10	-10	-12	-15	-20	-25	-31	-38	-40	-42	-44	-46	-44	-40
-70	-26	-20	-10	-4	0	1	1	0	0	0	-4	-10	-12	-16	-16	-16	-16	-16
-80	-20	-12	0	5	10	13	15	15	16	16	16	15	15	13	12	12	10	8
-90																		

Table of

average annual changes of eastern composition (δy) for the 1960 - 1965 period.
(γ/year)

φ \ λ	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
90	0																																			
80	9	7	4	3	0	-3	-5	-7	-10	-11	-11	-11	-11	-11	-11	-10	-7	-6	-4	-2	2	3	5	6	5	9	11	13	14	14	14	13	13	12	11	11
70	6	6	5	4	2	-2	-5	-9	-11	-12	-13	-13	-13	-12	-11	-10	-8	-6	-4	-1	2	3	4	6	6	7	8	10	10	10	9	8	7	6	5	5
60	15	14	9	6	3	-1	-5	-9	-12	-15	-16	-16	-14	-12	-10	-6	-5	-5	-5	-3	-2	-2	-2	-1	1	2	2	3	4	5	5	5	8	9	12	15
50	28	24	15	8	2	-4	-8	-11	-15	-16	-18	-16	-12	-9	-5	0	1	0	-3	-4	-6	-6	-6	-7	-8	-8	-9	-9	-6	-5	1	6	11	17	24	29
40	40	30	18	9	-1	-7	-12	-15	-15	-14	-15	-15	-11	-5	0	2	3	2	-1	-3	-5	-7	-9	-12	-13	-16	-18	-19	-19	-16	-10	0	14	24	35	41
30	50	33	19	10	-4	-12	-15	-13	-12	-10	-10	-13	-11	-5	1	5	6	3	1	-1	-4	-7	-11	-14	-16	-19	-25	-32	-34	-32	-22	-9	14	29	40	51
20	52	36	22	10	-10	-16	-15	-11	-8	-5	-8	-15	-19	-6	2	6	8	8	6	2	-2	-6	-12	-15	-20	-27	-34	-42	-50	-50	-43	-25	7	28	44	54
10	48	36	25	8	-20	-21	-17	-8	0	-4	-15	-21	-20	-8	1	9	12	12	10	7	1	-5	-12	-18	-24	-32	-42	-53	-62	-63	-57	-44	-10	21	38	50
0	40	35	26	20	-21	-23	-21	-9	-9	-20	-25	-20	-13	-4	5	12	14	15	13	10	3	-3	-12	-19	-26	-36	-47	-60	-67	-71	-65	-52	-30	5	26	39
-10	36	33	28	21	-20	-23	-24	-21	-22	-25	-20	-14	-5	3	9	14	16	18	17	14	5	-3	-10	-18	-28	-38	-50	-60	-70	-75	-70	-55	-38	-10	15	30
-20	31	32	28	20	-11	-23	-26	-27	-26	-23	-18	-8	1	6	10	16	20	21	21	18	8	0	-8	-16	-26	-36	-49	-60	-70	-72	-68	-55	-38	-15	8	24
-30	26	28	25	15	-8	-22	-27	-31	-31	-24	-15	-4	3	8	14	19	22	23	23	21	12	4	-5	-13	-22	-33	-44	-56	-64	-65	-62	-52	-36	-14	3	17
-40	21	21	19	7	-8	-22	-31	-36	-33	-23	-11	0	5	10	15	20	24	26	26	23	18	9	-2	-10	-18	-29	-39	-49	-58	-60	-56	-48	-34	-16	0	12
-50	10	10	5	-4	-17	-30	-41	-42	-36	-22	-10	1	6	11	16	20	24	27	26	25	21	14	4	-3	-10	-19	-29	-38	-45	-48	-46	-42	-30	-18	-5	5
-60	-3	-4	-8	-17	-30	-42	-42	-41	-28	-19	-8	2	7	13	17	20	23	25	25	23	22	20	12	4	-5	-11	-16	-23	-30	-34	-34	-35	-28	-22	-14	-8
-70	-19	-20	-20	-30	-40	-42	-40	-32	-24	-15	-7	2	7	14	18	21	23	23	23	23	22	21	20	14	8	2	-3	-10	-15	-20	-27	-30	-30	-30	-25	-21
-80	-30	-30	-30	-29	-30	-27	-25	-20	-15	-10	-2	2	10	15	20	20	21	22	22	21	21	21	21	20	20	15	7	0	-5	-12	-17	-23	-26	-26	-26	-30
-90																																				

Table of

average annual changes of vertical composition (δZ) for the 1960 - 1965 period. (γ/year)

	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
90	34																																			
80	36	37	38	39	40	40	42	44	45	44	42	41	38	33	28	25	22	20	18	18	16	15	16	17	19	22	24	28	30	33	34	34	35	36	36	36
70	28	27	27	27	26	26	26	25	25	24	20	16	12	10	8	6	7	7	6	4	0	-2	-4	-4	-2	0	9	16	22	28	31	31	31	31	30	30
60	18	22	27	24	21	18	16	12	10	5	-2	-4	-7	-10	-10	-10	-7	-5	-5	-5	-7	-12	-15	-16	-16	-14	-10	-4	6	14	20	21	20	18	16	16
50	7	17	22	21	17	13	8	5	2	-2	-6	-11	-15	-20	-22	-22	-21	-18	-14	-10	-10	-17	-22	-25	-27	-26	-24	-21	-16	-10	-2	0	-2	-3	-4	2
40	-4	10	22	22	18	11	5	1	-4	-7	-11	-15	-20	-25	-27	-27	-25	-23	-18	-14	-12	-18	-22	-30	-34	-36	-38	-40	-40	-40	-40	-40	-42	-40	-32	-16
30	-19	0	20	20	14	6	1	-5	-10	-12	-15	-18	-25	-30	-32	-31	-27	-24	-20	-14	-10	-16	-21	-30	-36	-44	-52	-60	-78	-92	-98	-90	-82	-78	-62	-44
20	-50	-20	1	6	4	0	-8	-15	-18	-18	-19	-24	-28	-34	-35	-33	-28	-23	-17	-12	-8	-10	-16	-24	-30	-42	-51	-65	-95	-125	-140	-130	-125	-120	-108	-80
10	-74	-47	-24	-10	-10	-10	-14	-20	-25	-27	-29	-32	-35	-38	-38	-34	-27	-21	-14	-8	-6	-6	-9	-15	-20	-30	-40	-50	-80	-110	-142	-145	-148	-141	-128	-104
0	-75	-55	-40	-24	-15	-10	-13	-20	-30	-34	-37	-40	-42	-41	-40	-32	-24	-15	-8	-3	0	1	0	-3	-7	-16	-25	-33	-50	-80	-120	-142	-140	-130	-112	-100
-10	-58	-43	-30	-20	-5	-2	-8	-20	-32	-39	-42	-42	-40	-36	-30	-25	-16	-8	-2	5	10	10	10	10	6	2	-5	-14	-28	-48	-78	-110	-120	-108	-93	-79
-20	-20	-1	10	24	25	16	-4	-22	-38	-46	-50	-40	-26	-20	-18	-12	-5	0	10	15	19	20	22	24	25	26	20	8	-3	-20	-40	-70	-80	-72	-60	-40
-30	24	40	67	40	44	20	-5	-29	-48	-50	-40	-20	-13	-8	-4	2	9	15	20	26	29	31	34	38	42	48	50	40	19	8	-10	-27	-32	-20	-9	8
-40	67	94	105	92	60	25	-10	-40	-54	-40	-20	-9	-2	4	10	15	20	26	31	37	39	42	47	51	60	70	75	70	50	38	25	20	20	24	31	44
-50	100	118	125	118	90	52	0	-40	-30	-4	7	12	20	24	26	30	32	39	44	49	51	55	60	68	80	90	98	92	80	70	61	60	60	64	70	85
-60	128	140	140	132	117	88	60	42	40	38	38	39	40	42	44	46	50	54	58	62	67	72	80	90	100	104	108	106	105	103	100	34	94	100	105	116
-70	140	140	140	140	130	120	108	90	80	78	74	70	70	70	70	70	72	75	80	82	88	92	98	105	112	116	120	121	121	120	120	120	121	126	130	136
-80	140	140	140	140	138	132	130	126	124	122	122	121	120	120	120	114	112	112	113	115	116	119	120	121	123	124	126	130	130	132	132	134	136	137	138	140
-90	130																																			

Table of

average annual changes of magnetic pole tension (δT) for the 1960 - 65 period. (γ/yr)

φ \ λ	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
90	35																																			
80	36	38	38	40	41	42	44	44	44	44	42	40	37	34	32	30	28	27	26	26	26	26	26	27	28	30	31	32	33	33	34	35	36	36	36	36
70	30	29	28	28	28	28	27	27	26	26	25	24	22	18	16	14	14	13	10	8	5	1	1	3	9	14	19	23	28	31	32	32	32	32	31	30
60	25	26	25	24	23	21	20	20	18	15	8	2	-1	-2	-2	-1	-1	-1	-2	-4	-6	-8	-9	-10	-7	-3	2	6	12	16	20	23	24	24	24	24
50	22	25	27	28	22	17	15	12	7	3	-1	-1	-3	-4	-5	-6	-6	-8	-9	-10	-12	-14	-17	-19	-20	-18	-12	-10	-8	-6	-4	0	3	8	14	18
40	19	25	30	29	20	16	13	9	6	2	-2	-2	-3	-6	-8	-9	-10	-10	-11	-12	-14	-18	-22	-28	-30	-32	-30	-28	-26	-28	-30	-26	-20	-8	2	10
30	15	23	28	27	20	16	13	9	6	2	-2	-2	-2	-2	-4	-4	-6	-9	-10	-12	-15	-18	-24	-32	-38	-44	-50	-50	-60	-65	-66	-50	-36	-20	-8	4
20	10	20	24	24	20	16	12	10	7	4	0	0	3	2	0	-2	-5	-7	-10	-13	-16	-19	-24	-30	-38	-46	-55	-64	-76	-100	-96	-70	-50	-34	-17	0
10	6	13	20	22	16	10	7	8	10	13	17	20	18	15	10	2	-3	-7	-10	-12	-16	-19	-25	-32	-40	-48	-58	-67	-78	-96	-100	-80	-58	-38	-18	-5
0	-2	6	8	8	4	2	2	5	12	19	24	26	24	22	14	5	-2	-6	-10	-16	-18	-21	-28	-34	-42	-50	-60	-67	-76	-84	-86	-80	-53	-32	-17	-10
-10	-25	-20	-12	-16	-19	-19	-10	4	20	30	34	30	22	20	13	5	-3	-8	-14	-16	-20	-26	-32	-38	-46	-54	-62	-68	-75	-72	-66	-60	-40	-30	-22	-26
-20	-53	-60	-60	-60	-48	-32	-10	20	34	40	35	22	15	8	5	-2	-8	-13	-18	-22	-28	-32	-36	-42	-52	-60	-66	-70	-73	-65	-54	-40	-35	-39	-41	-46
-30	-80	-90	-100	-93	-70	-34	0	34	47	42	30	11	0	-4	-6	-10	-15	-20	-25	-30	-35	-39	-44	-52	-58	-66	-75	-78	-75	-68	-60	-50	-54	-60	-64	-70
-40	-102	-118	-124	-110	-80	-34	20	47	50	40	14	-4	-10	-14	-16	-20	-26	-30	-36	-40	-43	-48	-52	-58	-68	-76	-82	-85	-84	-81	-80	-80	-80	-82	-86	-92
-50	-120	-140	-140	-112	-90	-40	10	43	40	12	-6	-16	-24	-30	-34	-38	-40	-44	-45	-48	-52	-58	-63	-70	-78	-84	-90	-94	-94	-92	-92	-92	-95	-100	-106	-113
-60	-138	-140	-136	-117	-92	-68	-41	-20	-20	-28	-37	-40	-44	-46	-47	-50	-52	-54	-56	-60	-66	-72	-76	-81	-87	-92	-98	-102	-102	-102	-102	-104	-107	-112	-116	-124
-70	-134	-132	-130	-120	-105	-96	-86	-82	-80	-78	-74	-70	-68	-66	-64	-66	-68	-70	-76	-78	-80	-86	-92	-96	-100	-102	-105	-107	-110	-110	-112	-114	-116	-119	-126	-128
-80	-124	-124	-120	-120	-115	-112	-110	-108	-106	-105	-104	-102	-102	-101	-101	-100	-100	-100	-102	-102	-102	-103	-104	-106	-107	-108	-110	-112	-114	-115	-115	-117	-118	-121	-124	-124
-90	-112																																			

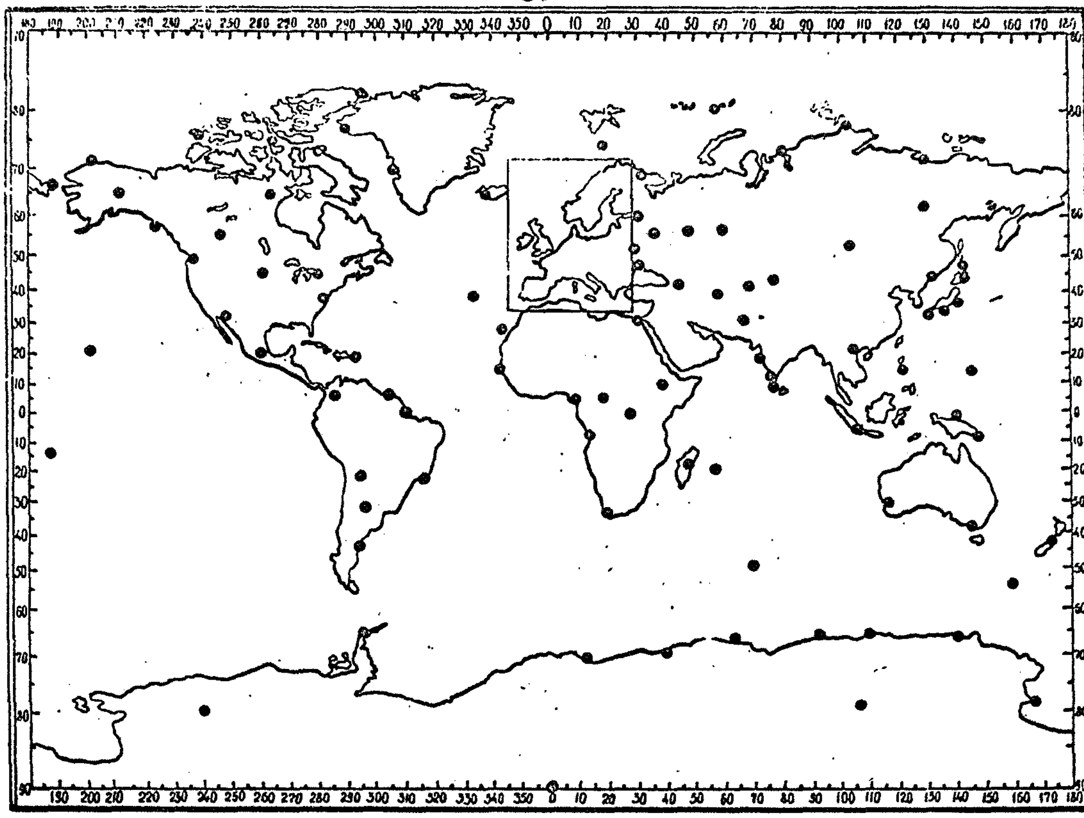


Fig. 1

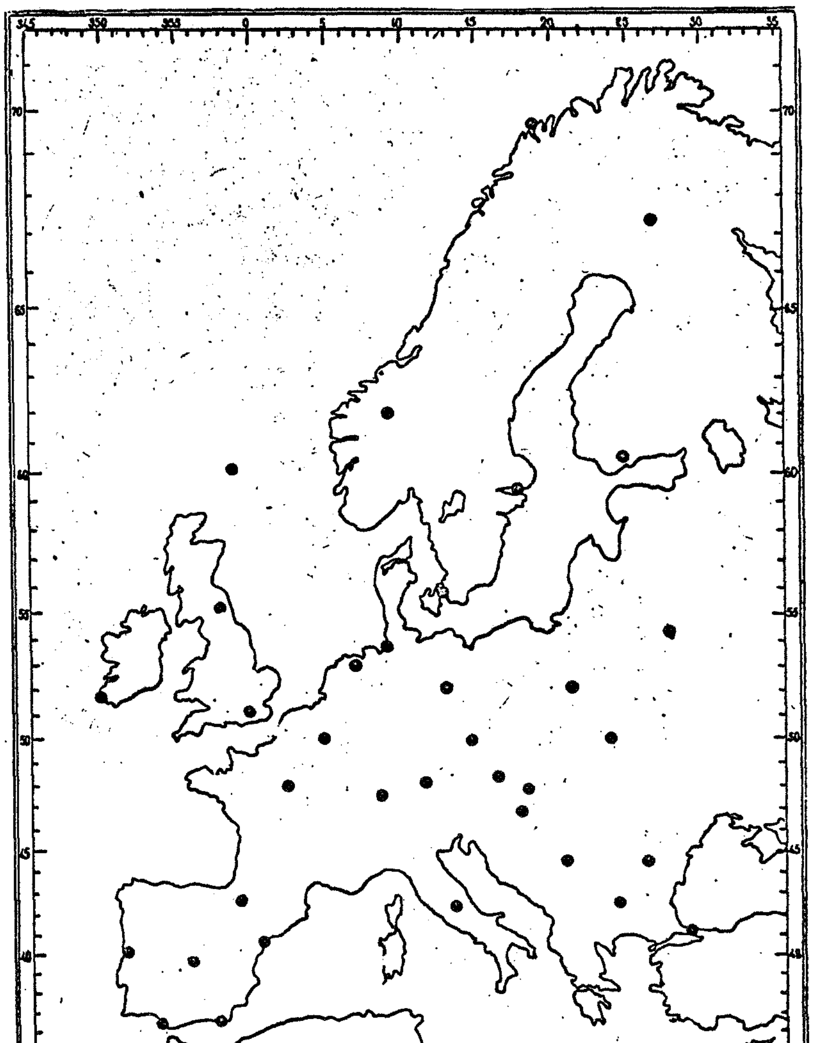
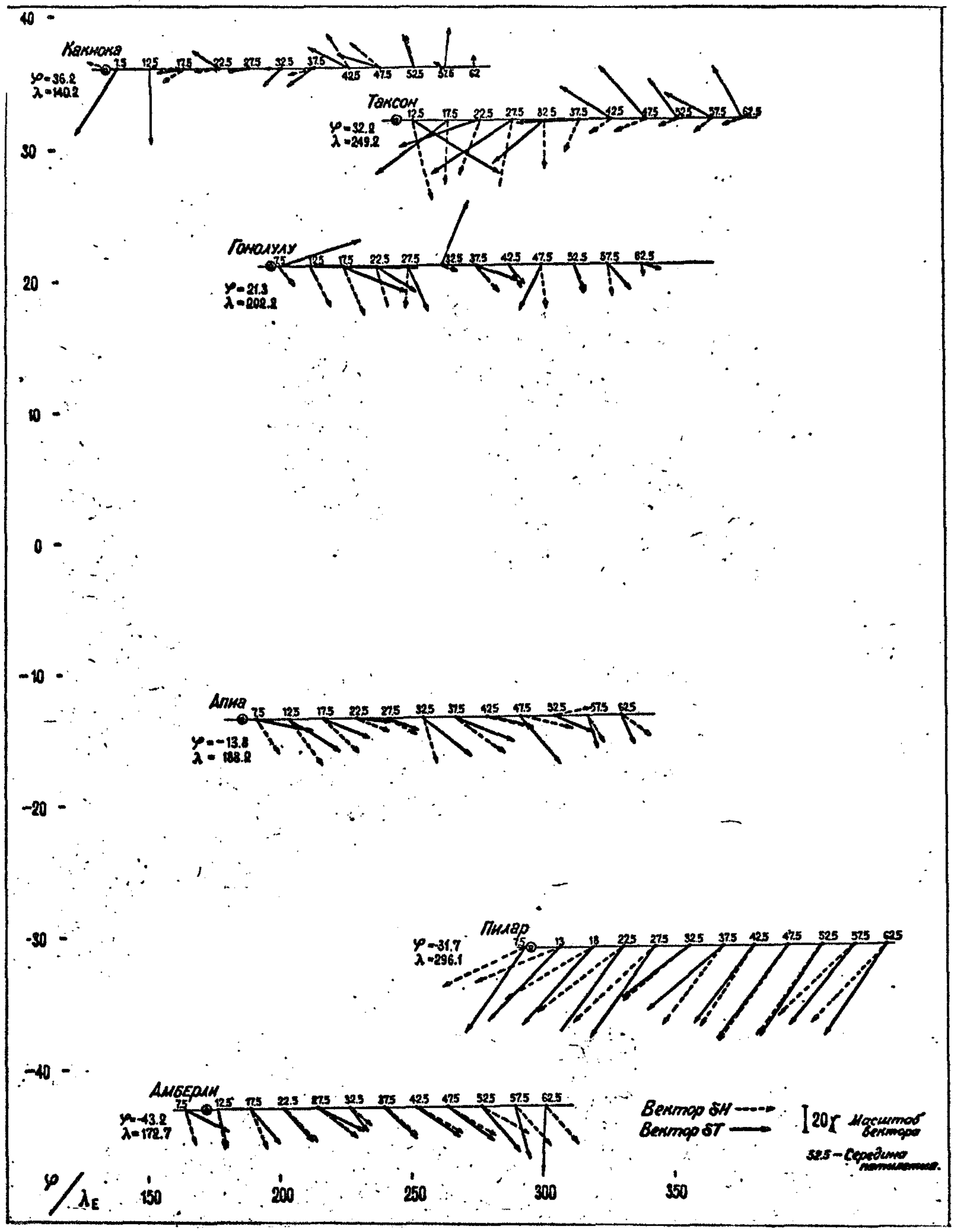


Fig. 1-o

Vector δ T and δ H



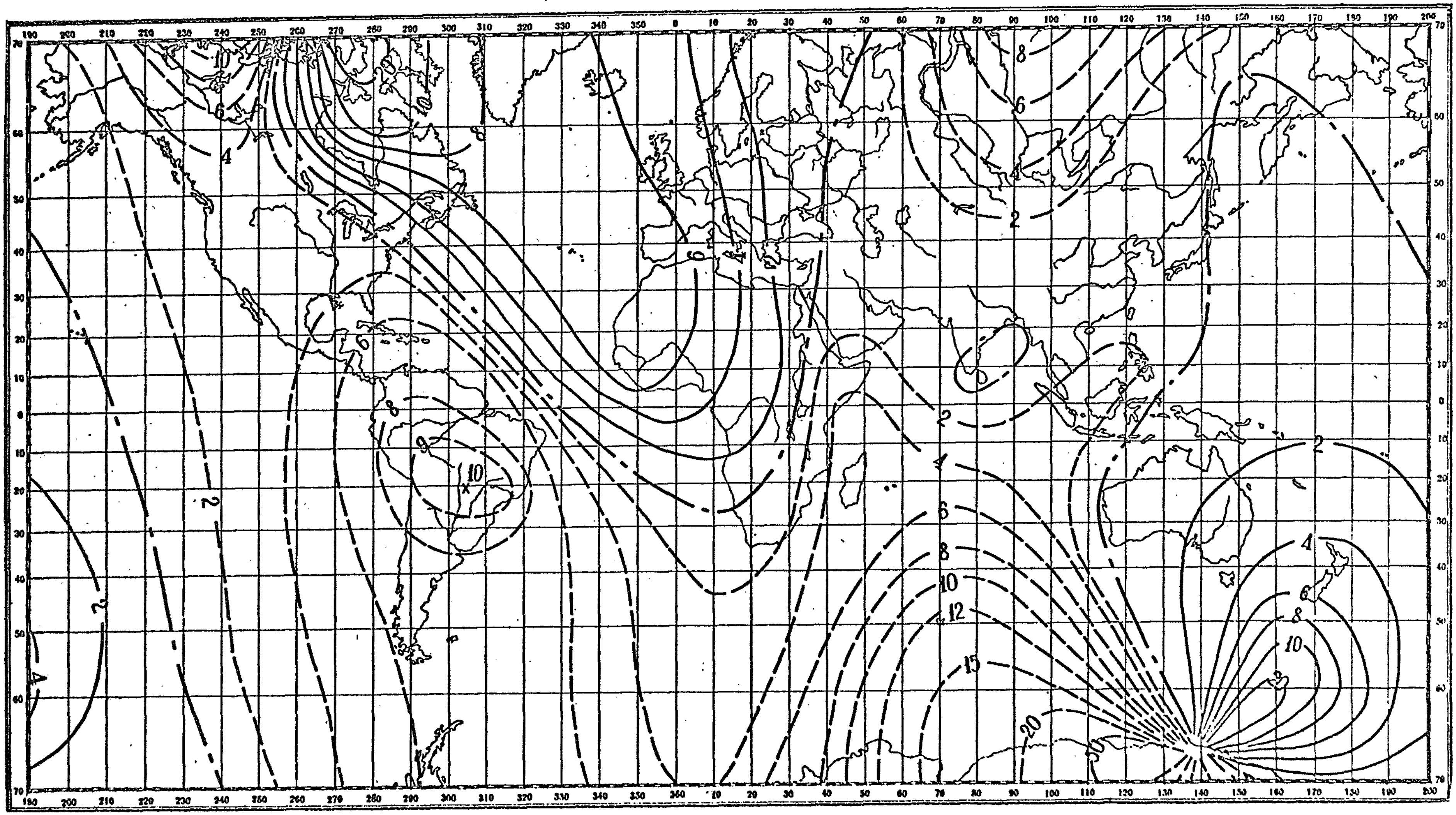
Vector δ H---------

Vector δ T————

I 20γ vector scale

52.5--center of 5 yr. period.

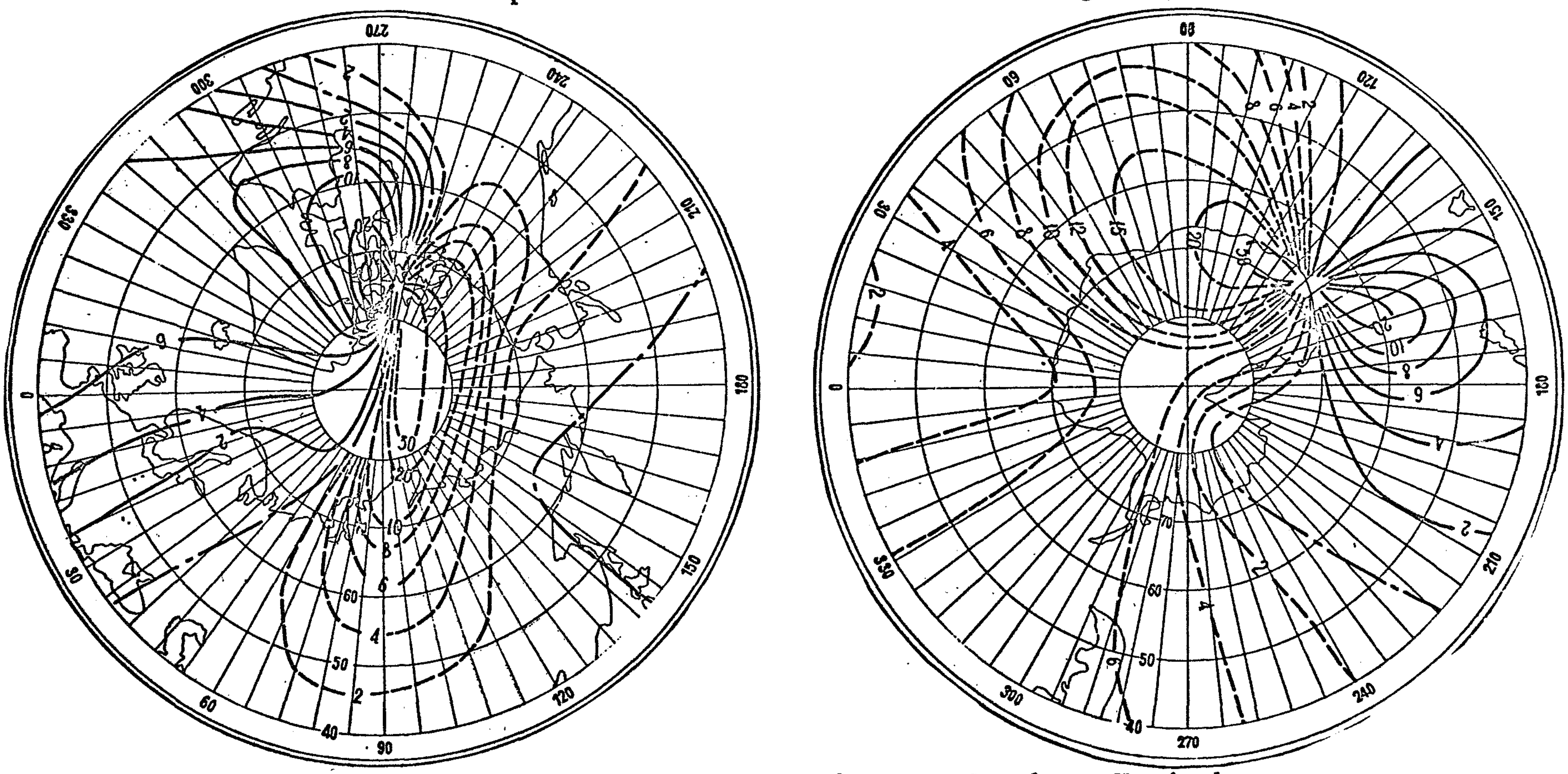
Isoperiodic chart D for the 1960 - 1965 Period (min/year).



—— - ——— zero values

------------ netagive values--east declination diminishes; west grows

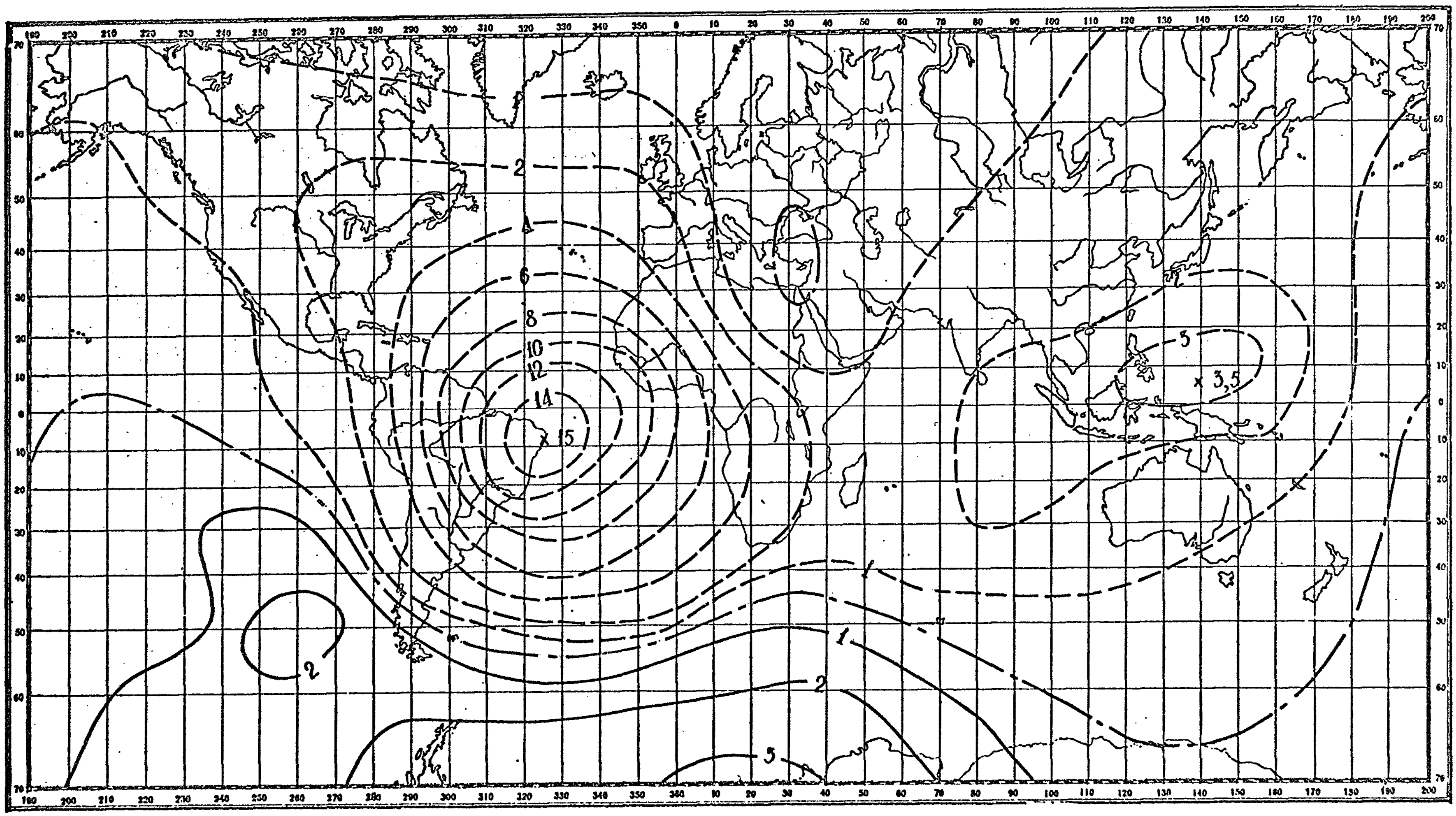
———————— pósitive values--east declination grows; west diminishes



Northern Hemisphere Fig. 3 Southern Hemisphere

δD (Graphic Method)

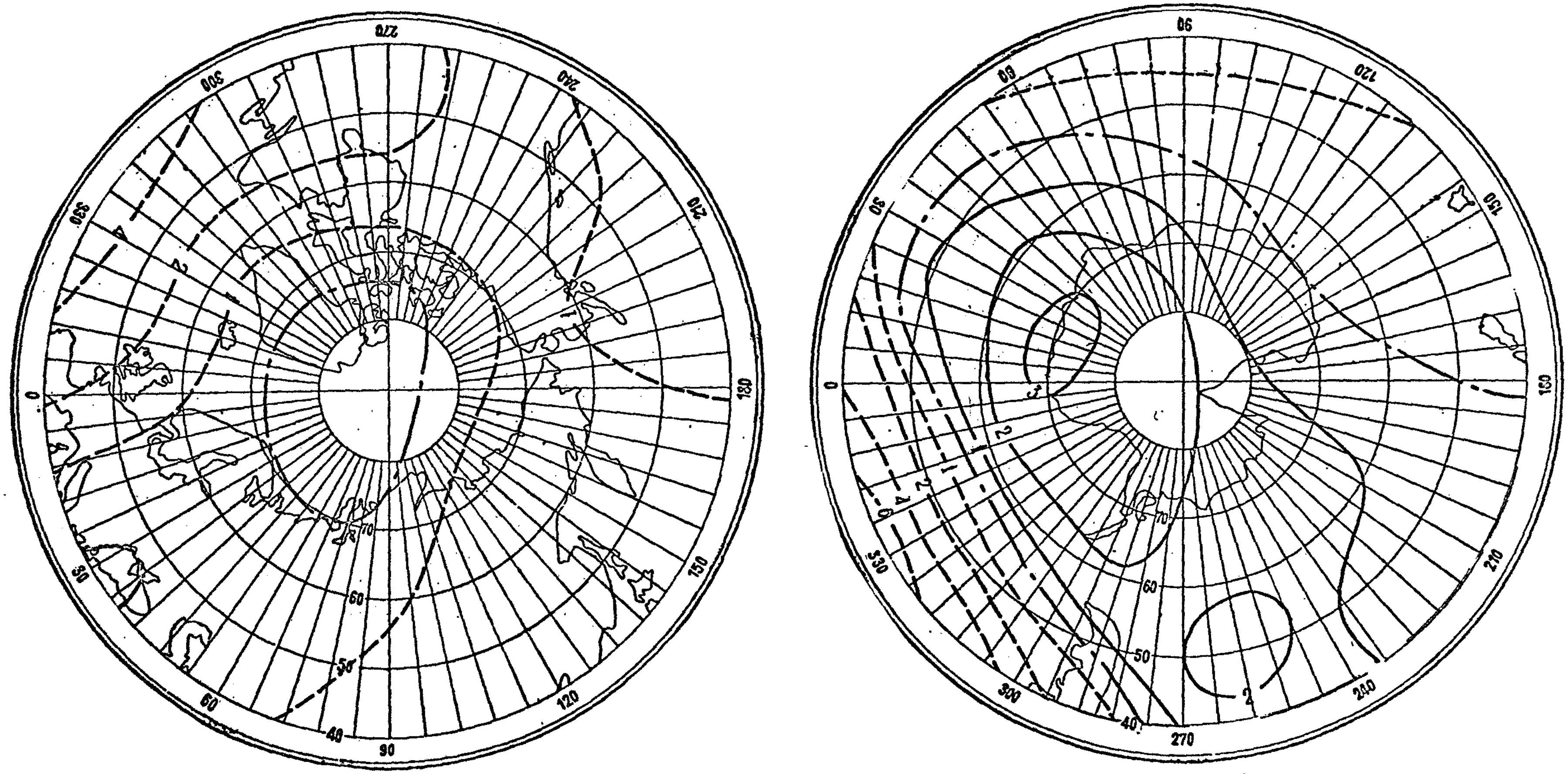
Isoperiodic Chart I for the 1960 - 1965 Period (min/yr).



— - — zero values

--------- negative values

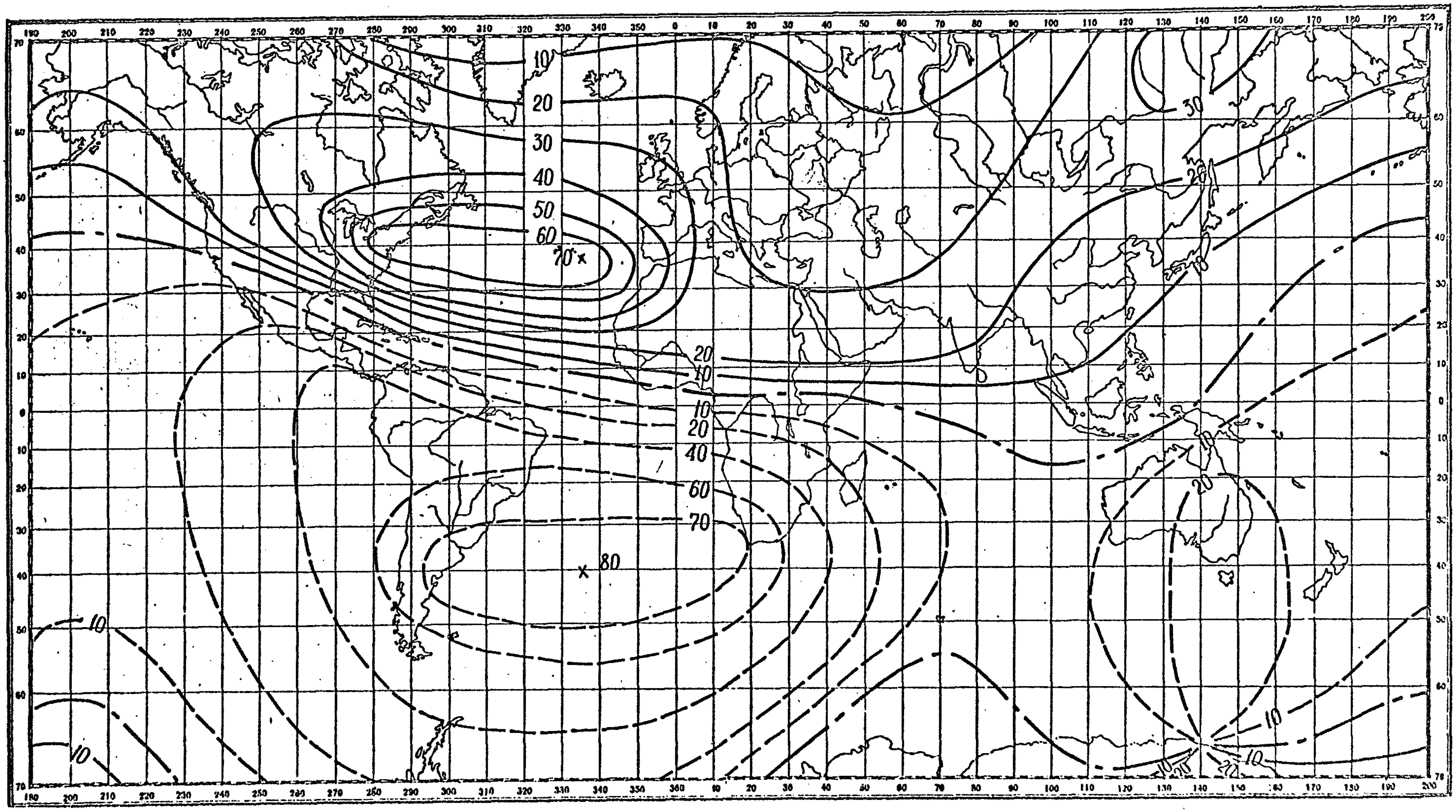
———— positive values



Northern Hemisphere Fig. 4 Southern Hemisphere

δI (Graphic Method)

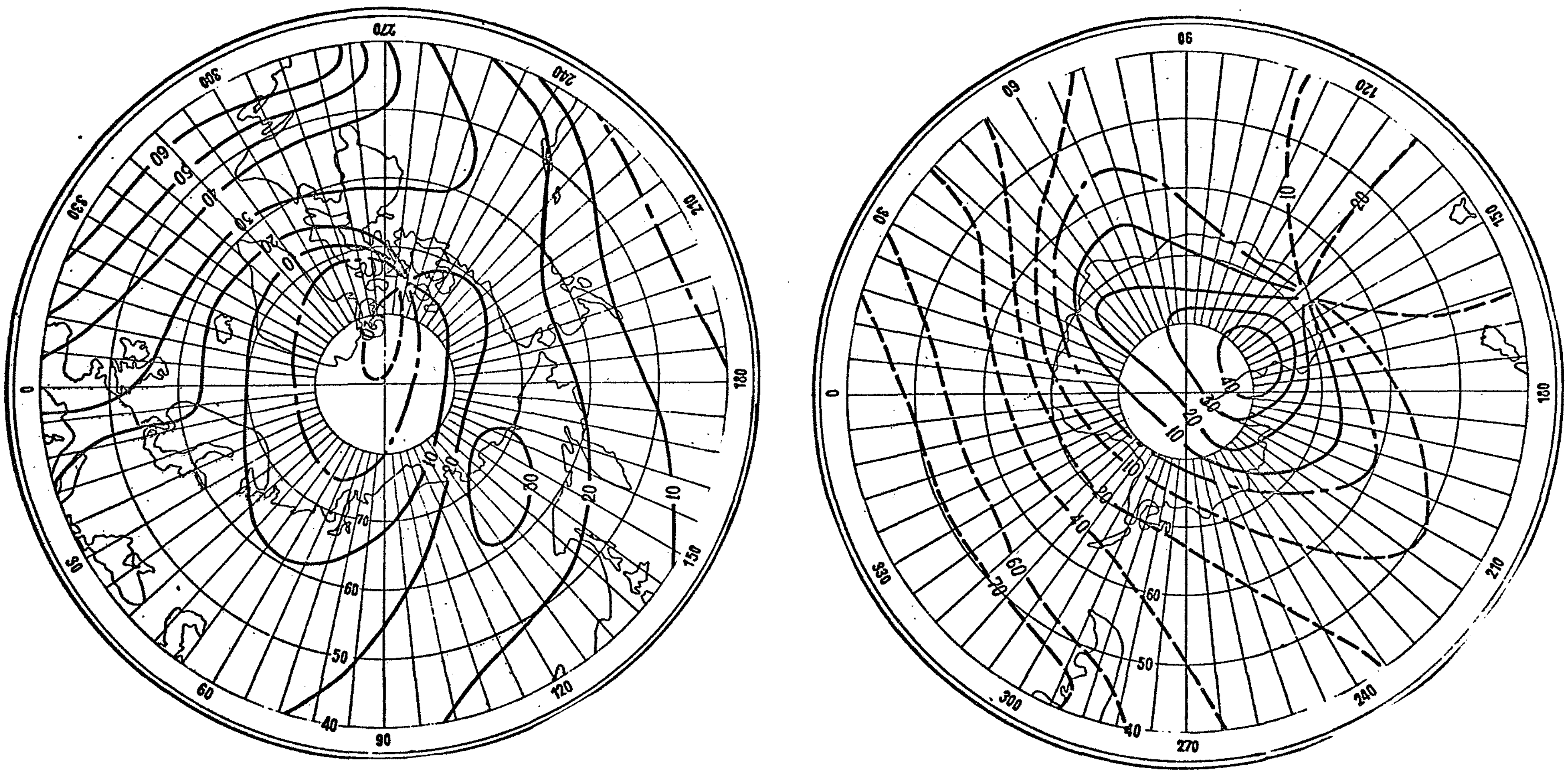
Isoperiodic Chart H for the 1960 - 1965 Period (γ/year).



— - — zero values

--------- negative values

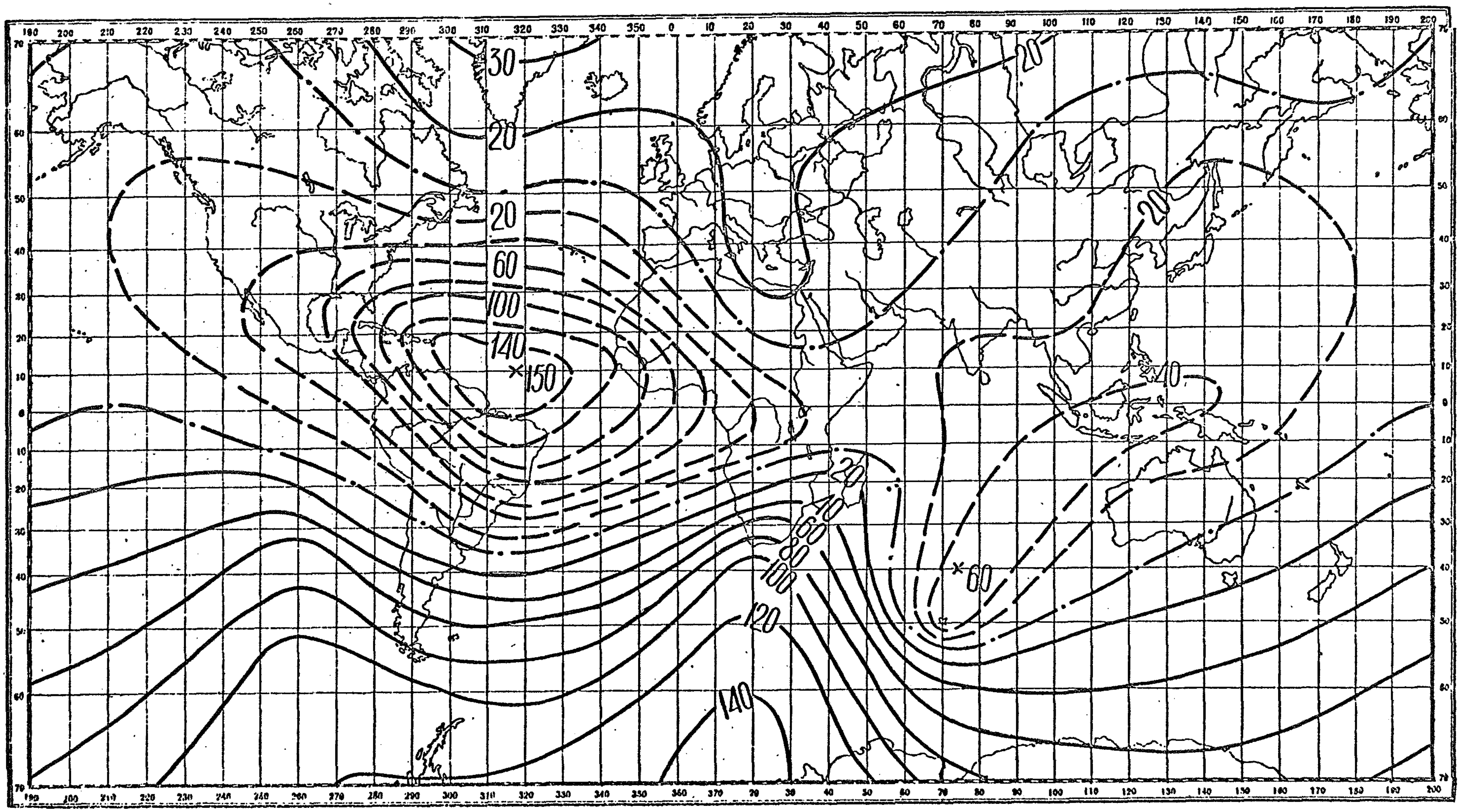
———— positive values



Northern Hemisphere Fig. 5 Southern Hemisphere

δH (Graphic Method)

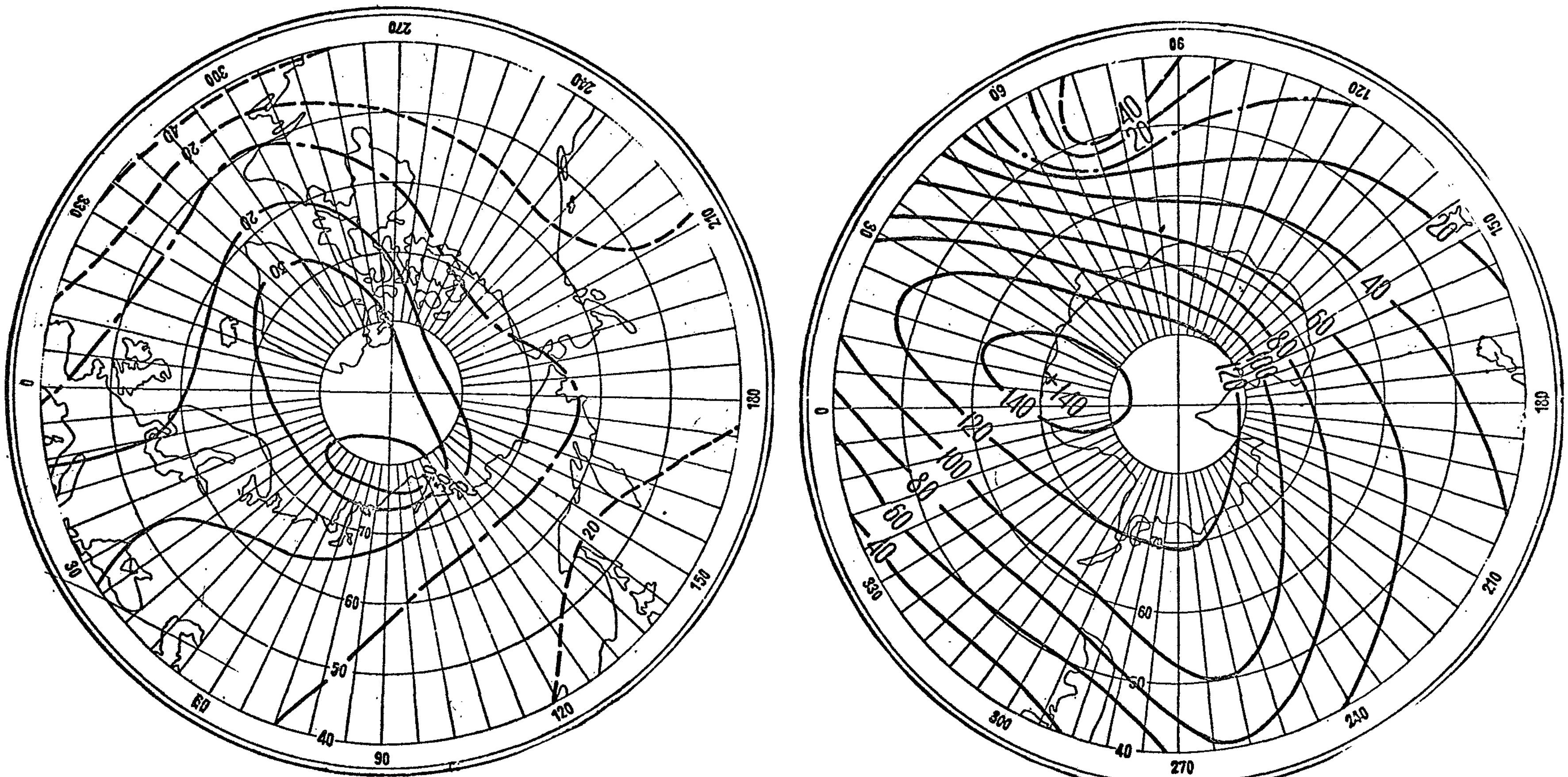
Isoperiodic Chart Z for the 1960 - 1965 Period (γ/year).



—— - —— zero values

---------- negative values

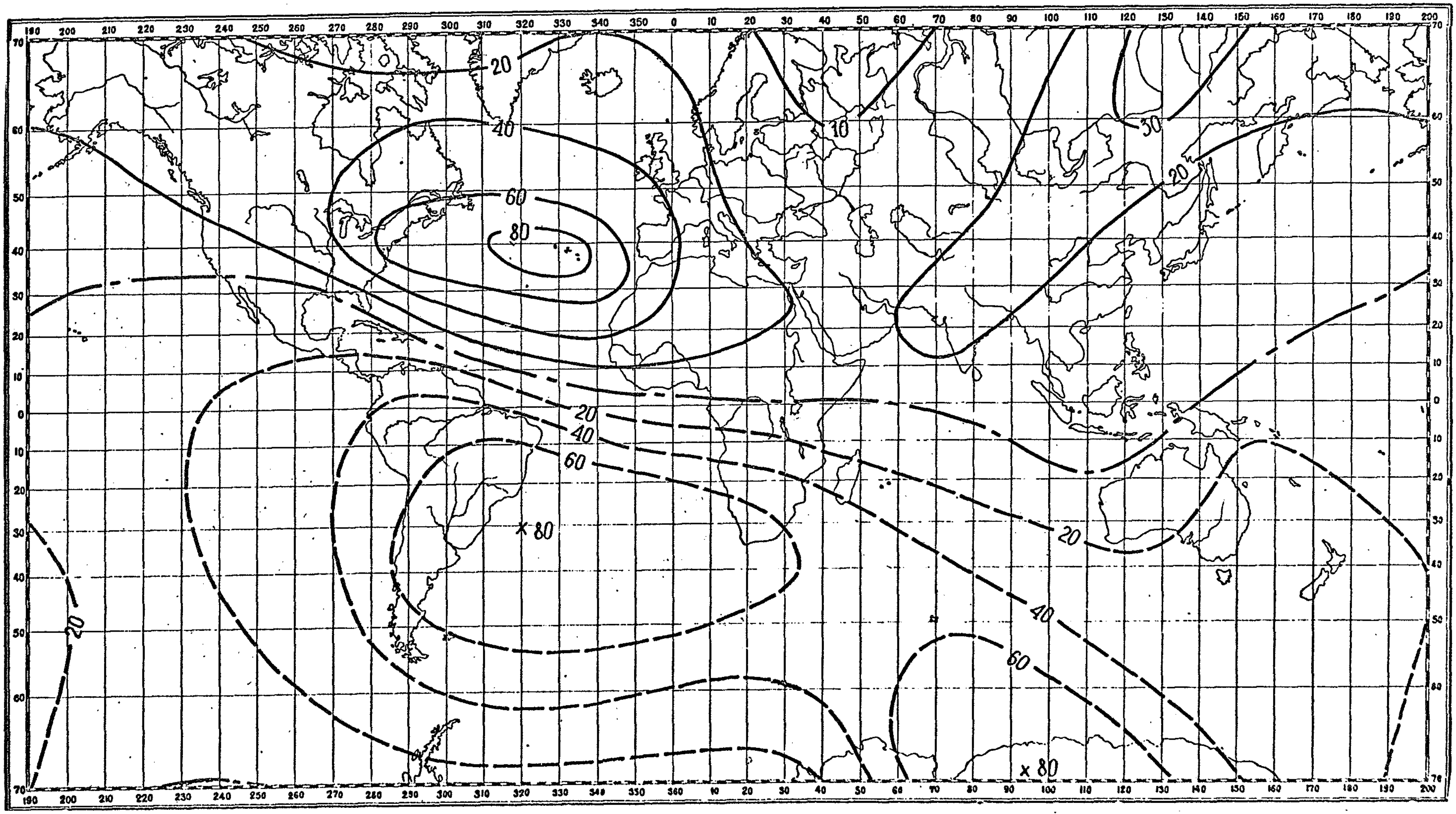
―――――――― positive values



Northern Hemisphere Fig. 6 Southern Hemisphere

δZ (Graphic Method)

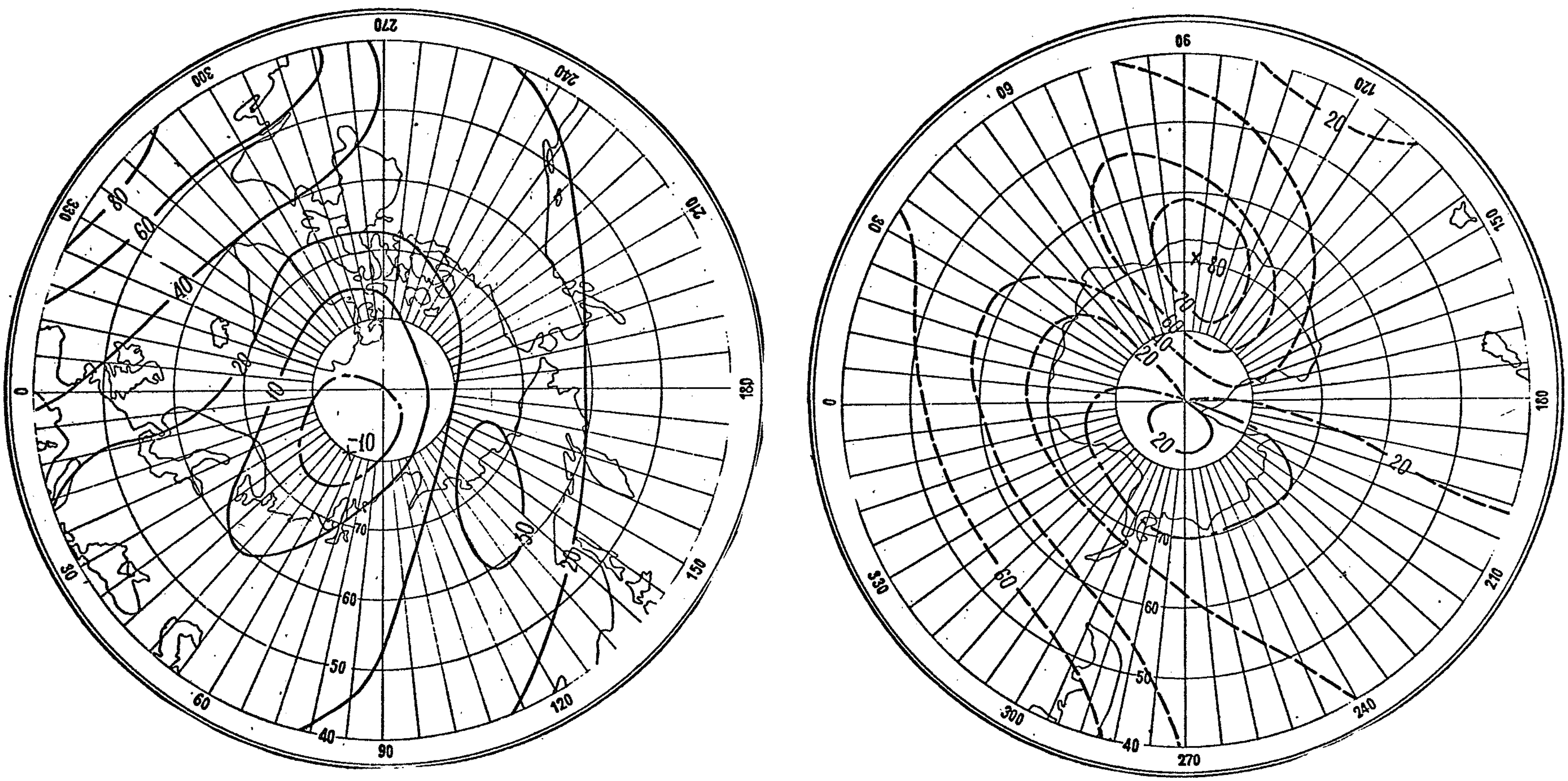
Isoperiodic Chart X for the 1960 - 1965 Period (γ/year).



—— - —— zero values

--------- negative values

———————— positive values



Northern Hemisphere Fig. 7 Southern Hemisphere

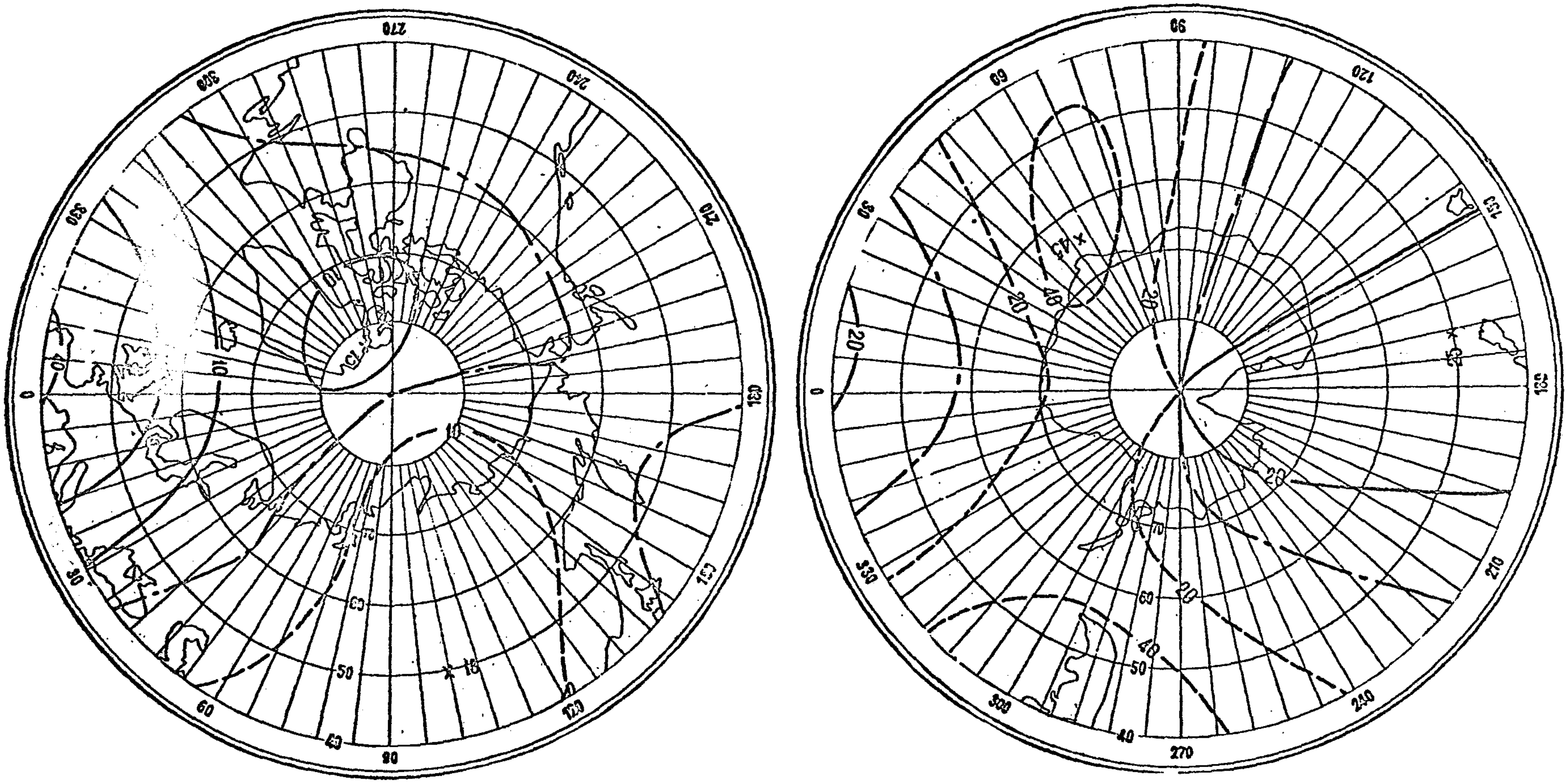
δ X (Graphic Method)

Isoperiodic Chart Y for the 1960 - 1965 Period (γ/year).

—— - —— zero values

---------- negative values

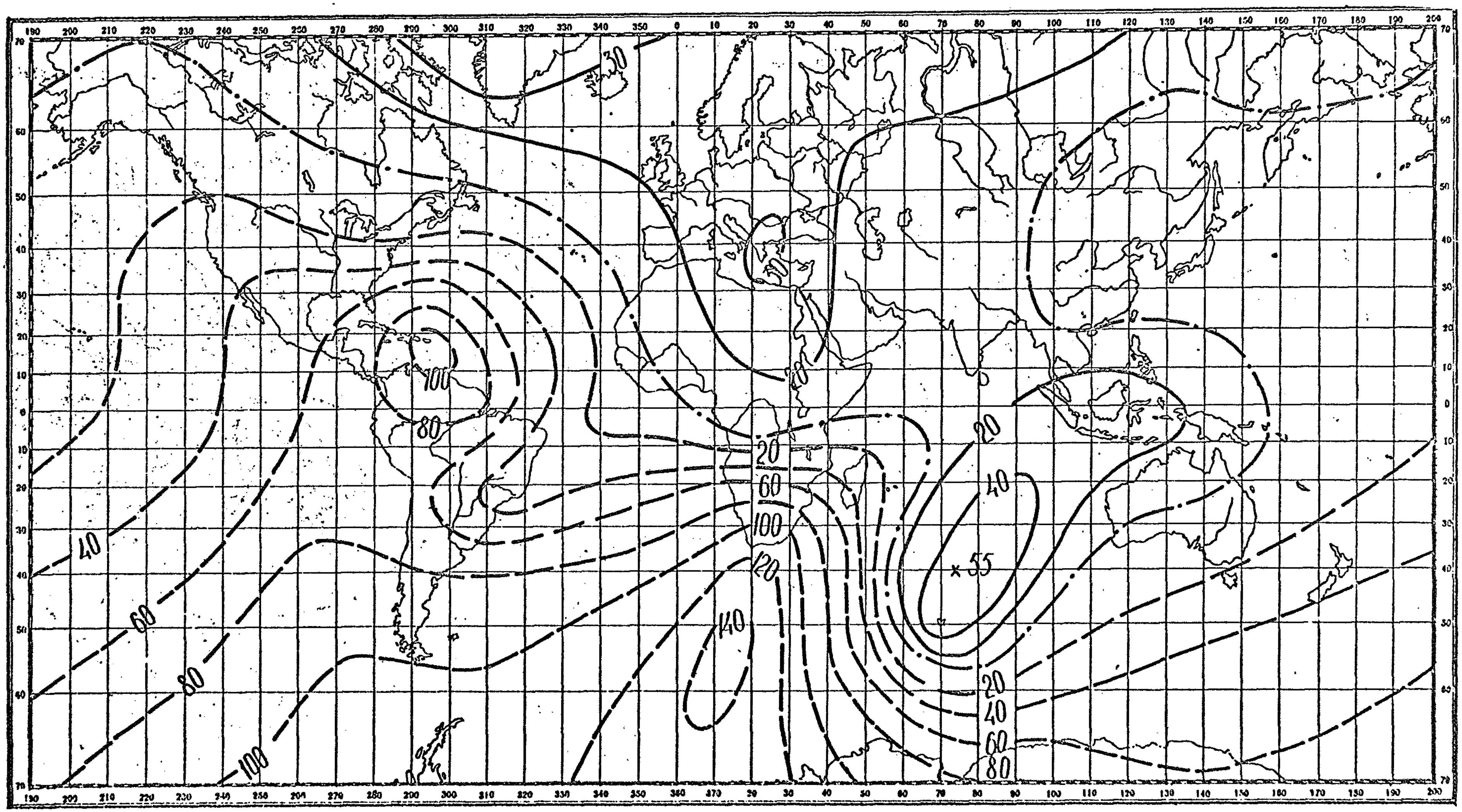
———————— positive values



Northern Hemisphere Fig. 8 Southern Hemisphere

δY (Graphic Method)

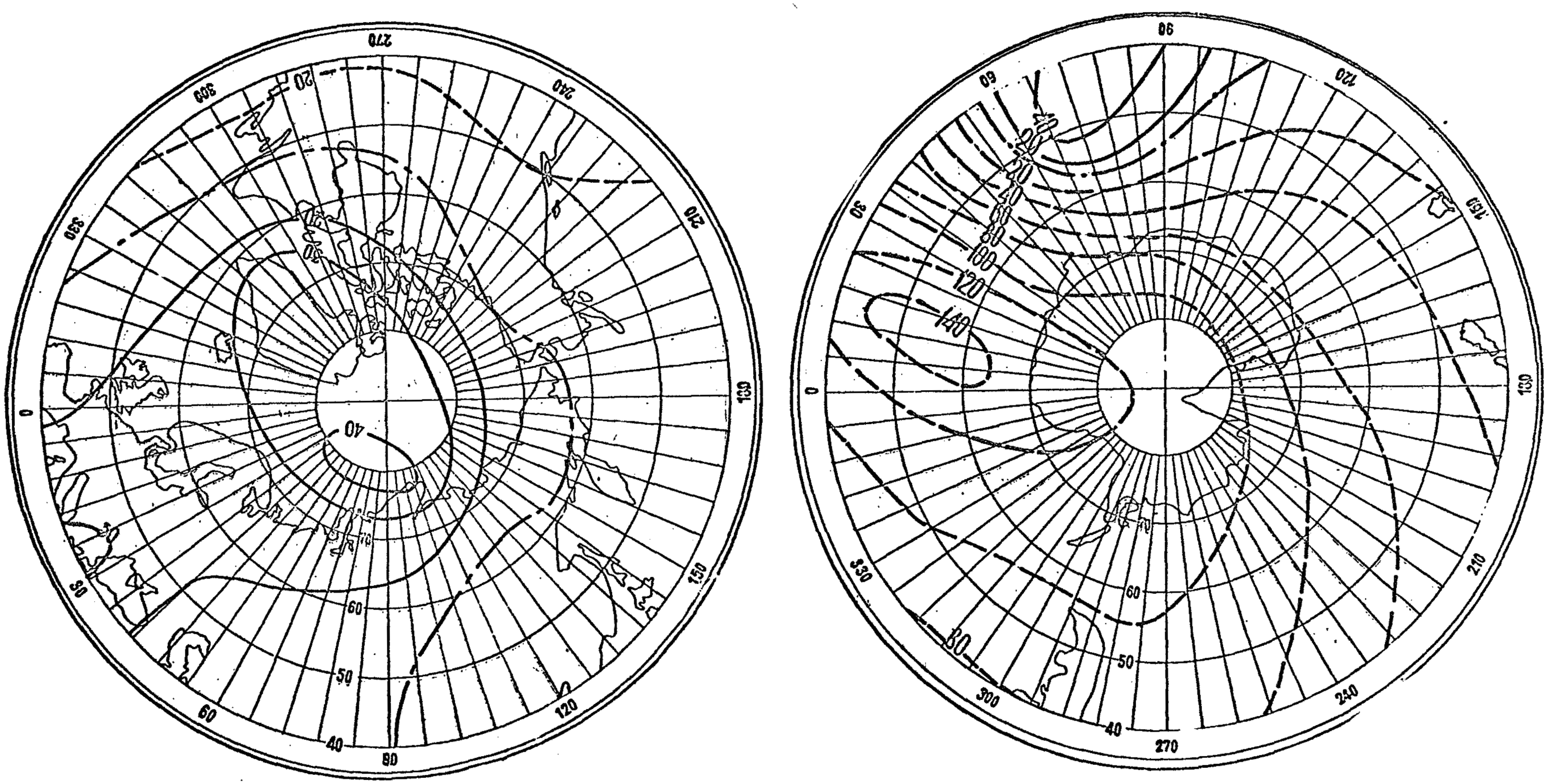
Isoperiodic Chart T for the 1960 - 1965 Period (γ/year).



— - — zero values

-------- negative values

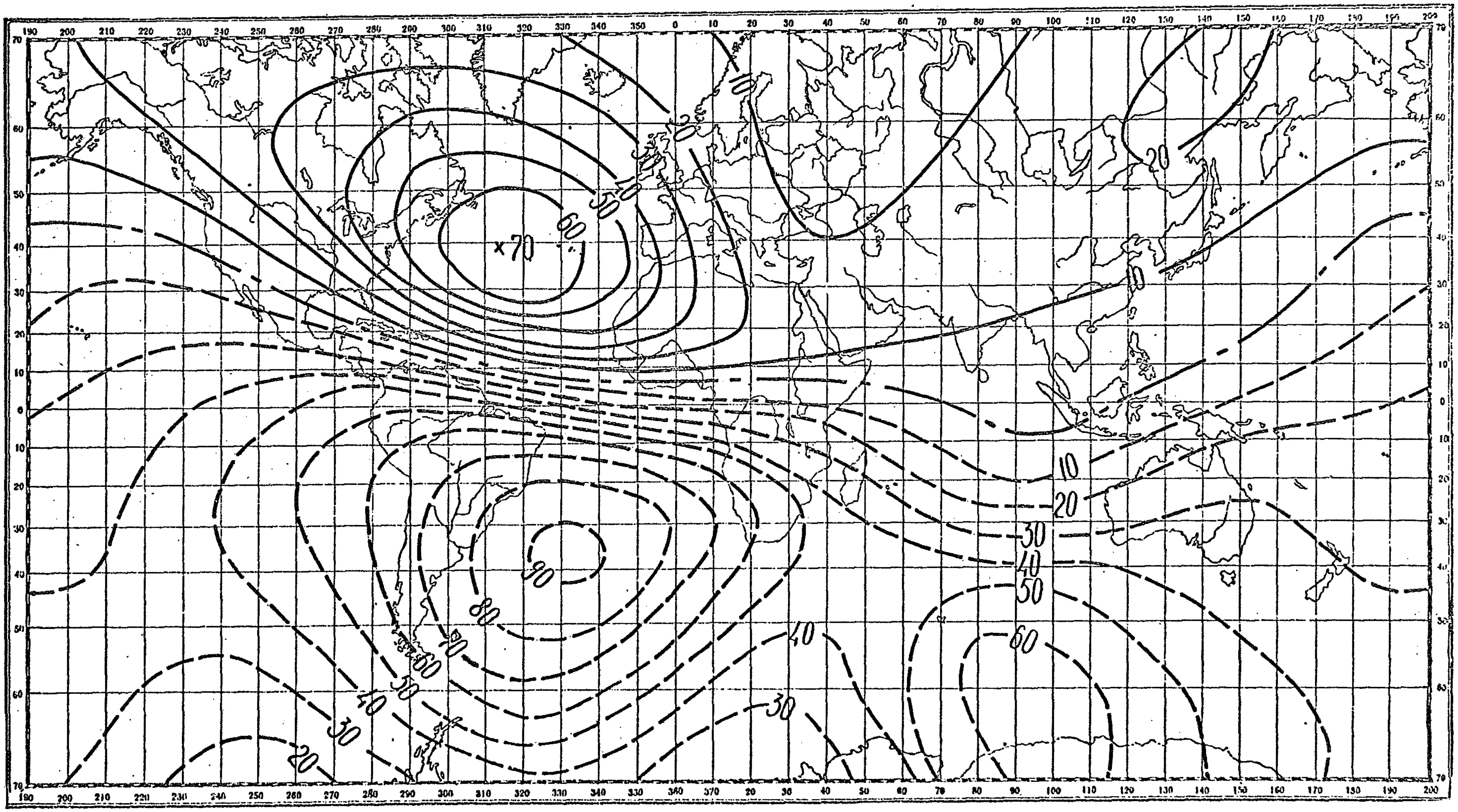
———— positive values



Northern Hemisphere Fig. 9 Southern Hemisphere

δT (Graphic Method)

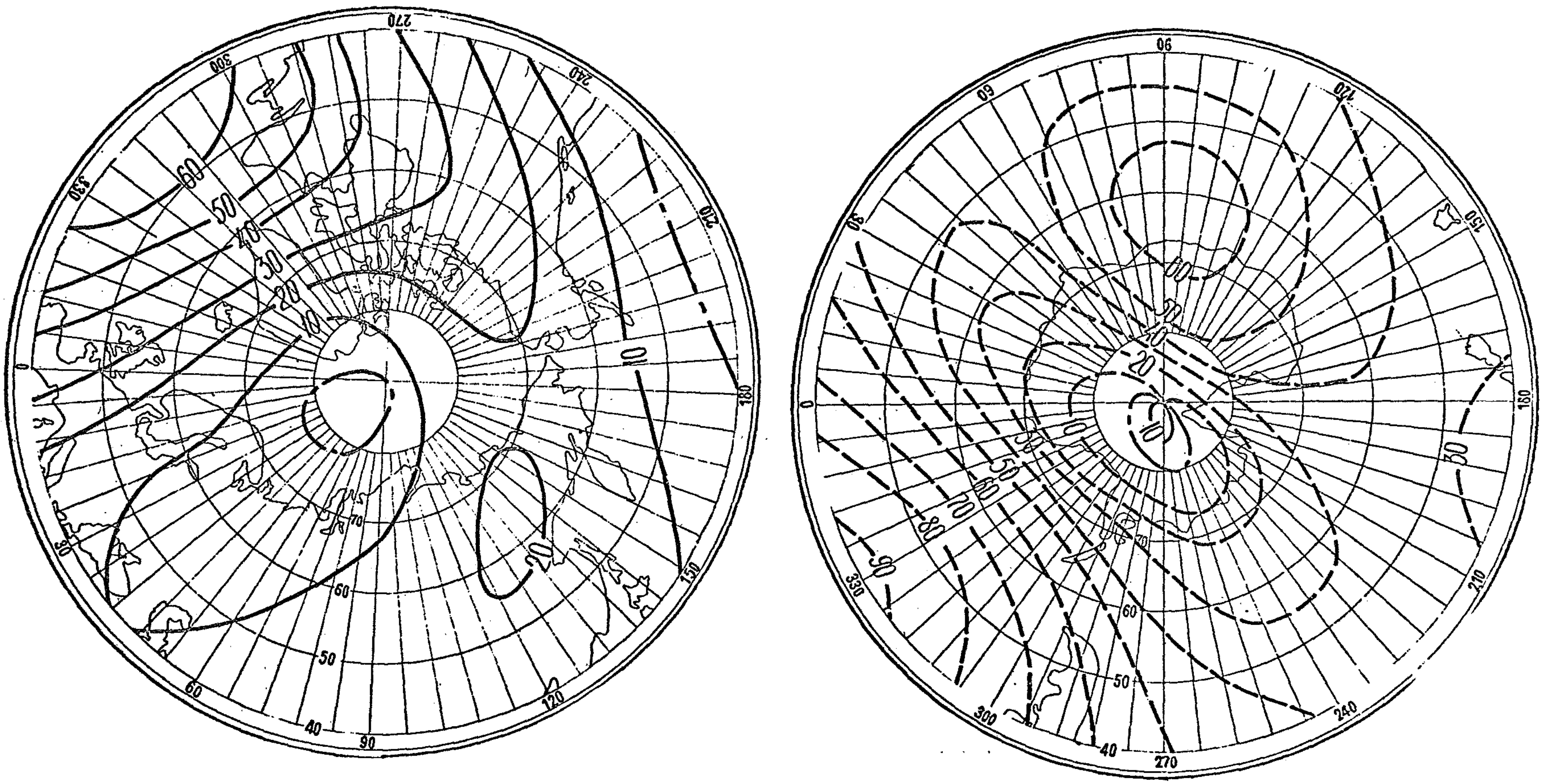
Isoperiodic Chart X for the 1960 - 1965 Period (γ/yr).



zero values

negative values

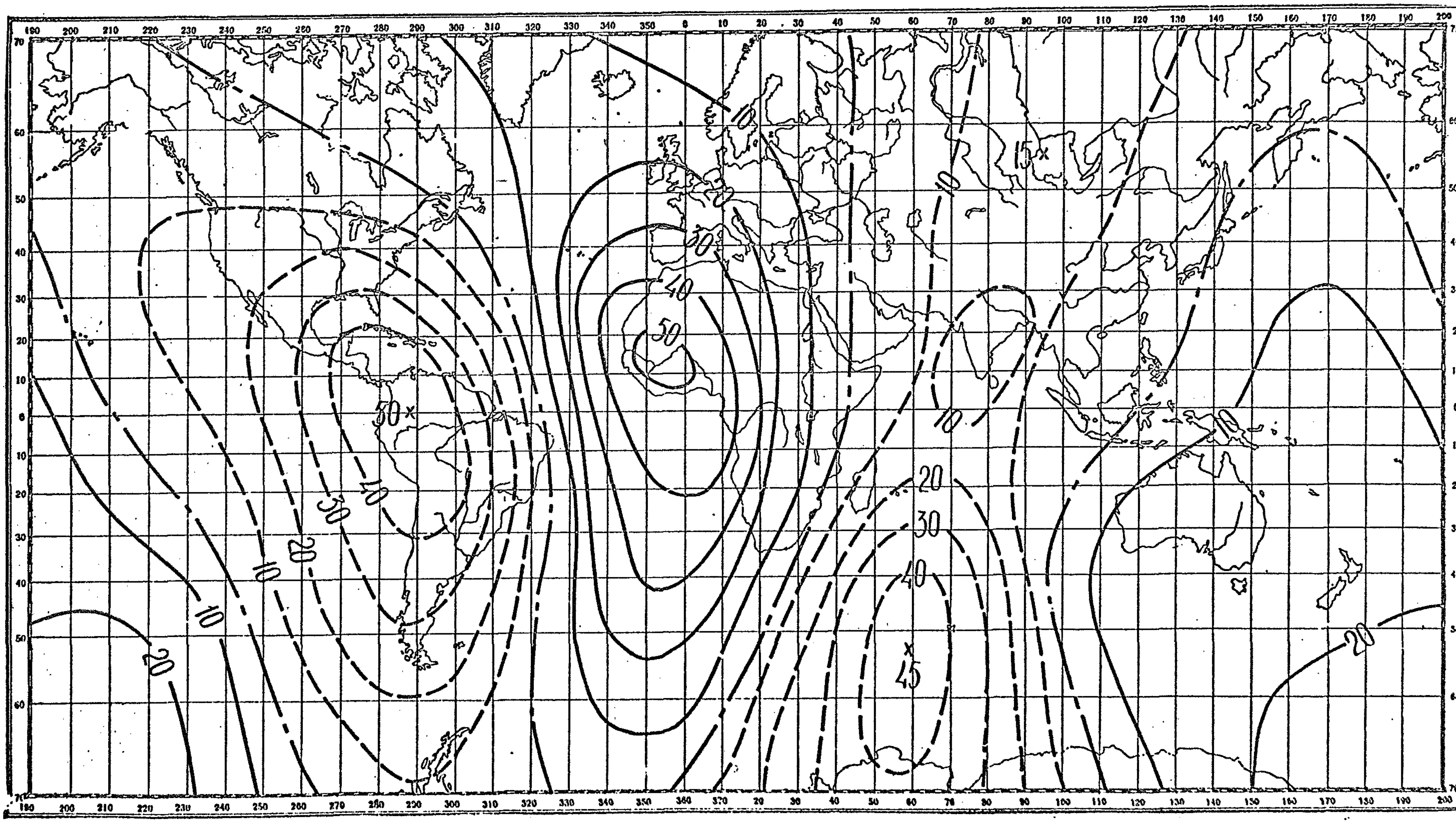
positive values



Northern Hemisphere Fig. 10 Southern Hemisphere

δX (Graph-analytic Method)

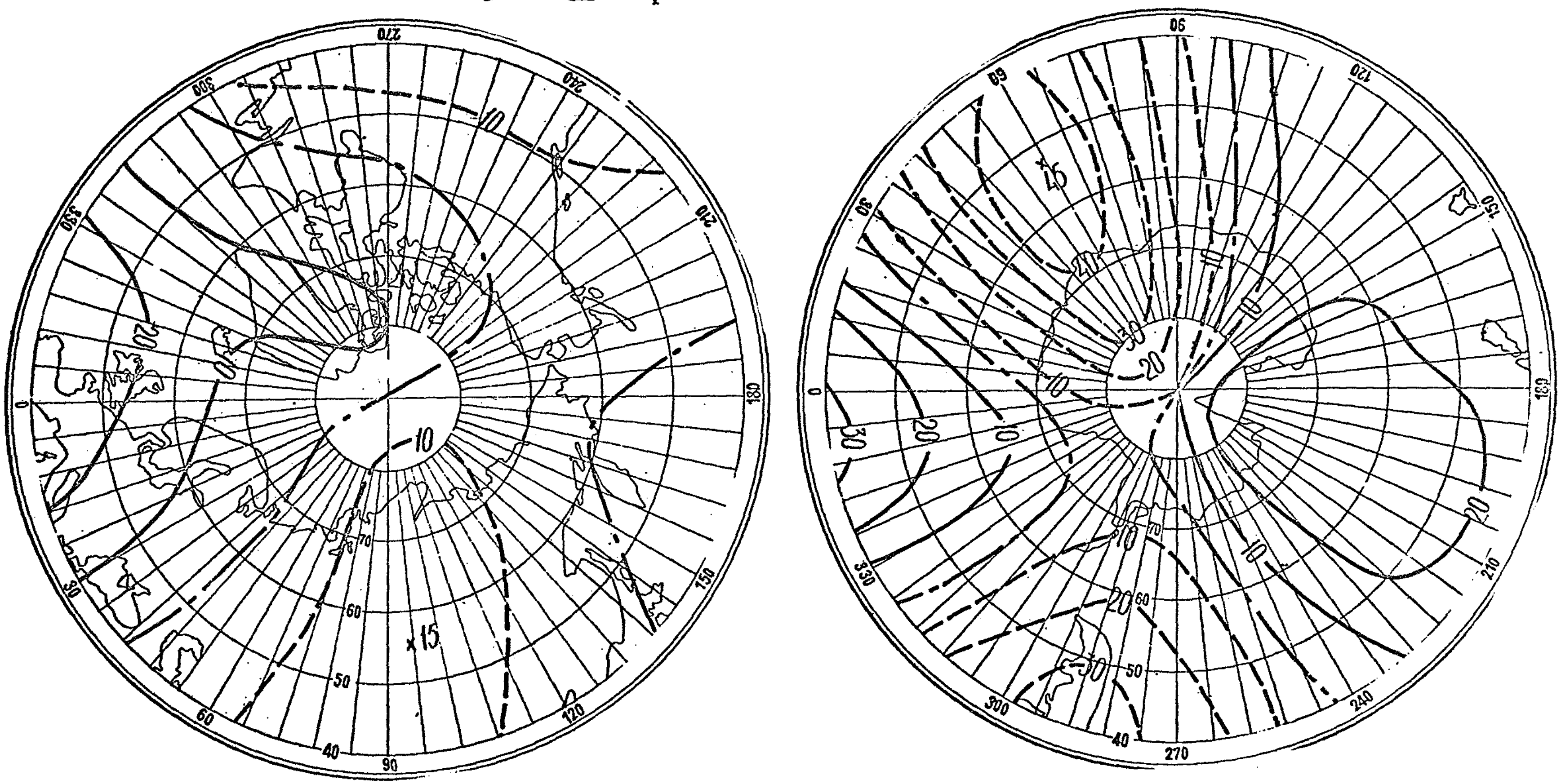
Isoperiodic Chart Y for the 1960 - 1965 Period (γ/yr).



~ - ~ zero values

negative values

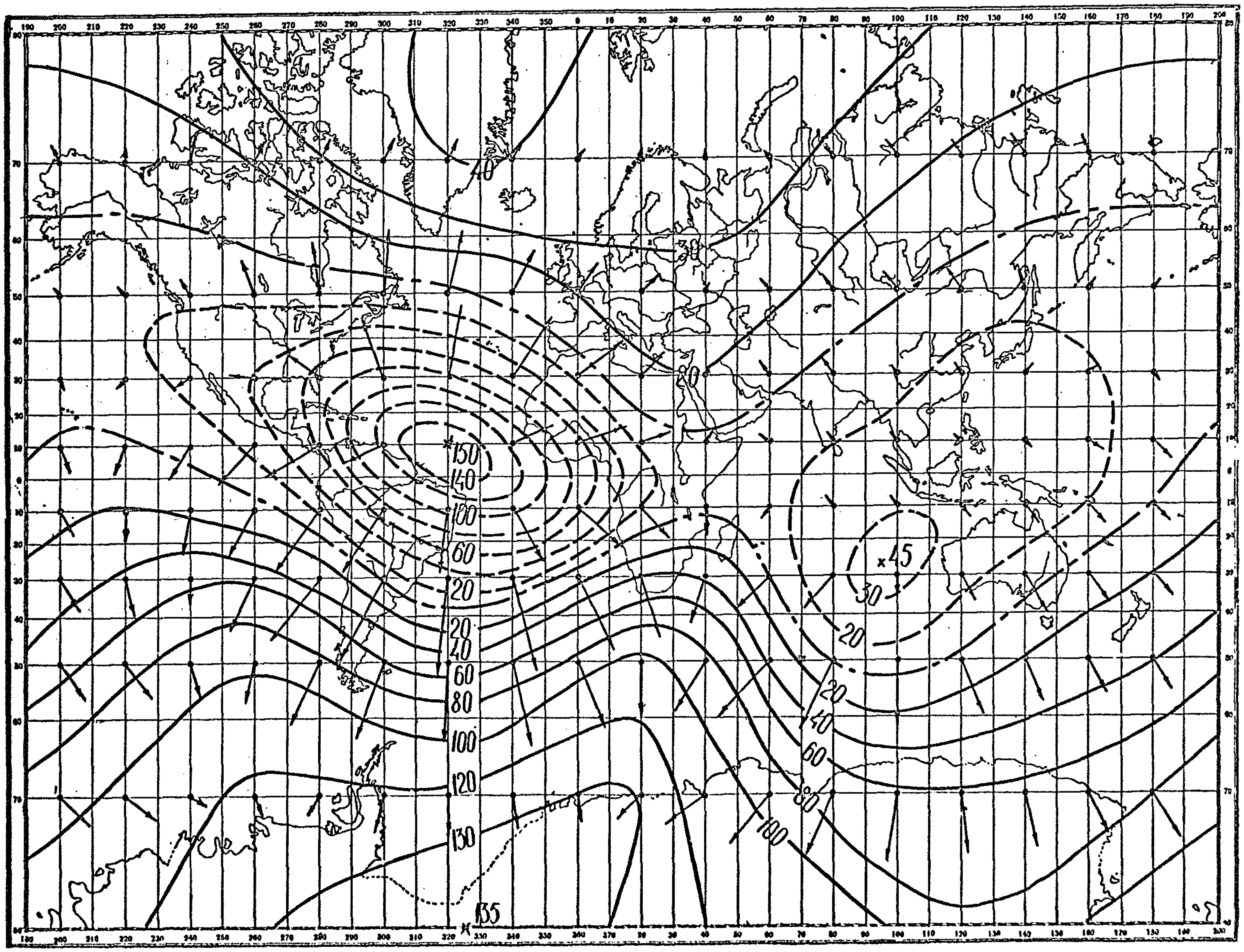
- - - positive values



Northern Hemisphere Fig. 11 Southern Hemisphere

δY (Graph-analytic Method)

Isoperiodic Chart Z and δ H Vectors for the 1960 - 1965 Period. (γ/yr)

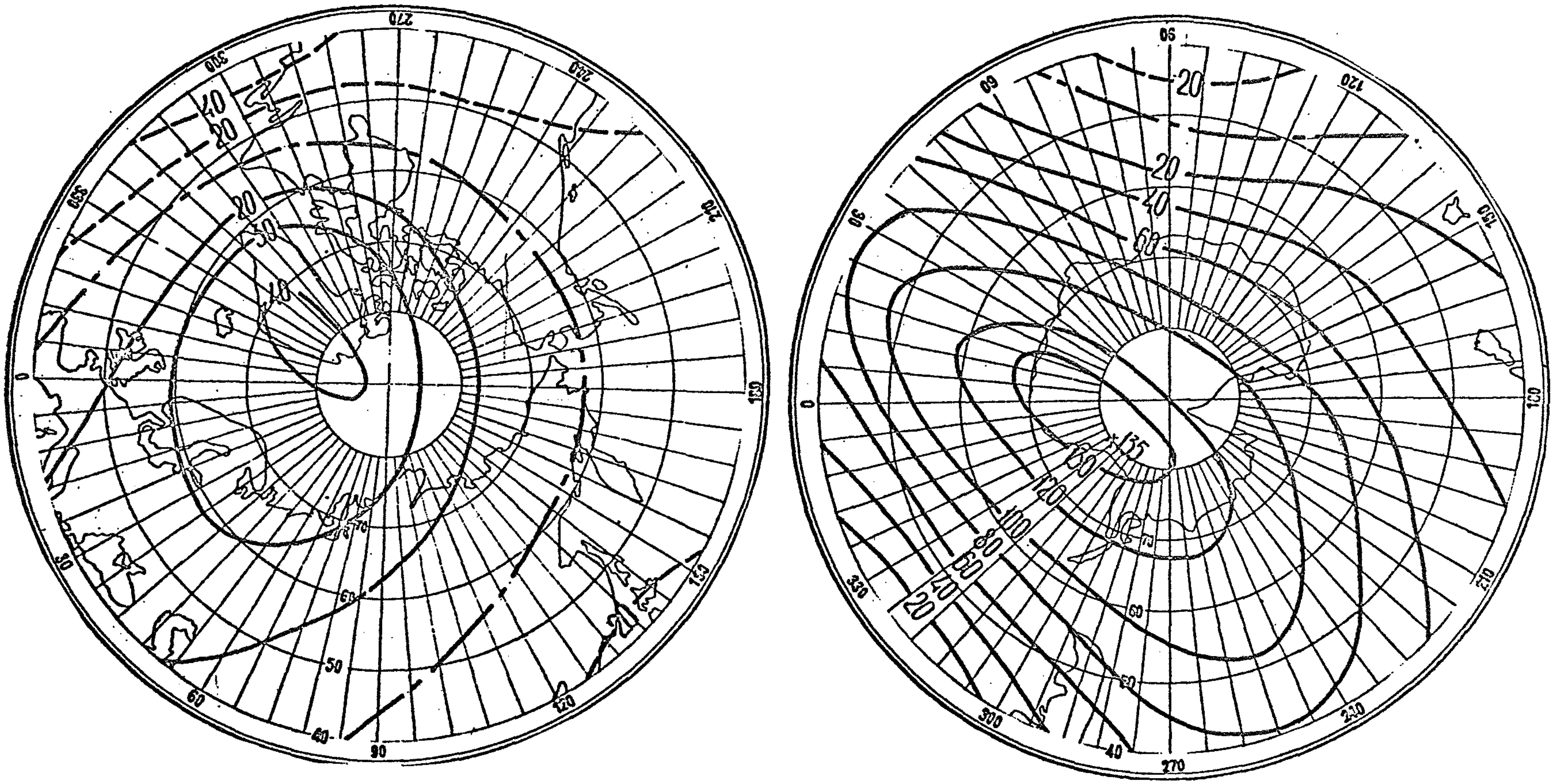


zero values

negative values

positive values

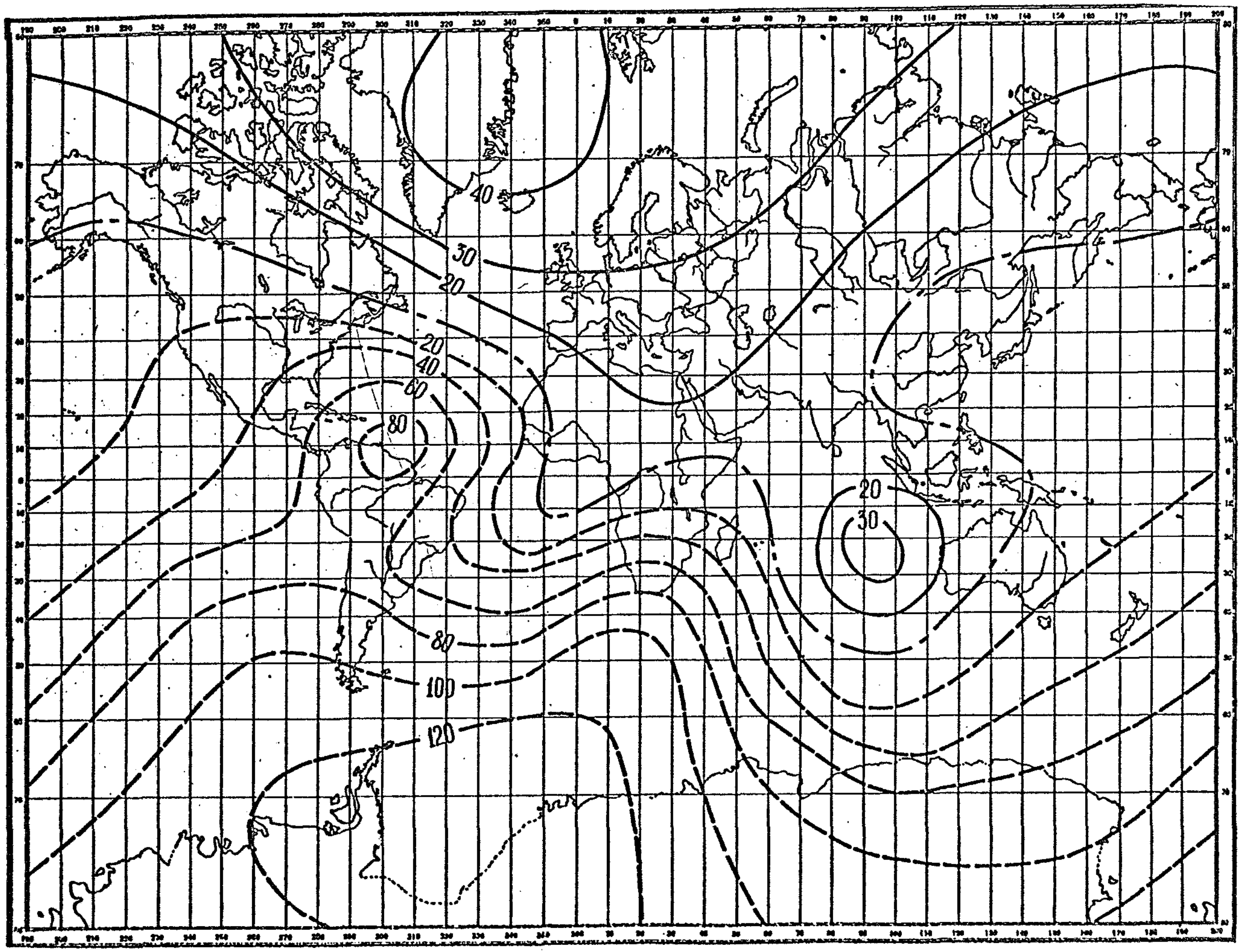
$\overline{\delta H} \rightarrow 30\gamma$



Northern Hemisphere Fig. 12 Southern Hemisphere

δZ (Graph-analytical Method)

Isoperiodic Charts T for the 1960 - 1965 Period. (γ/yr)



δT--Graph-analytical Method

Fig. 13

zero values

positive values

negative values

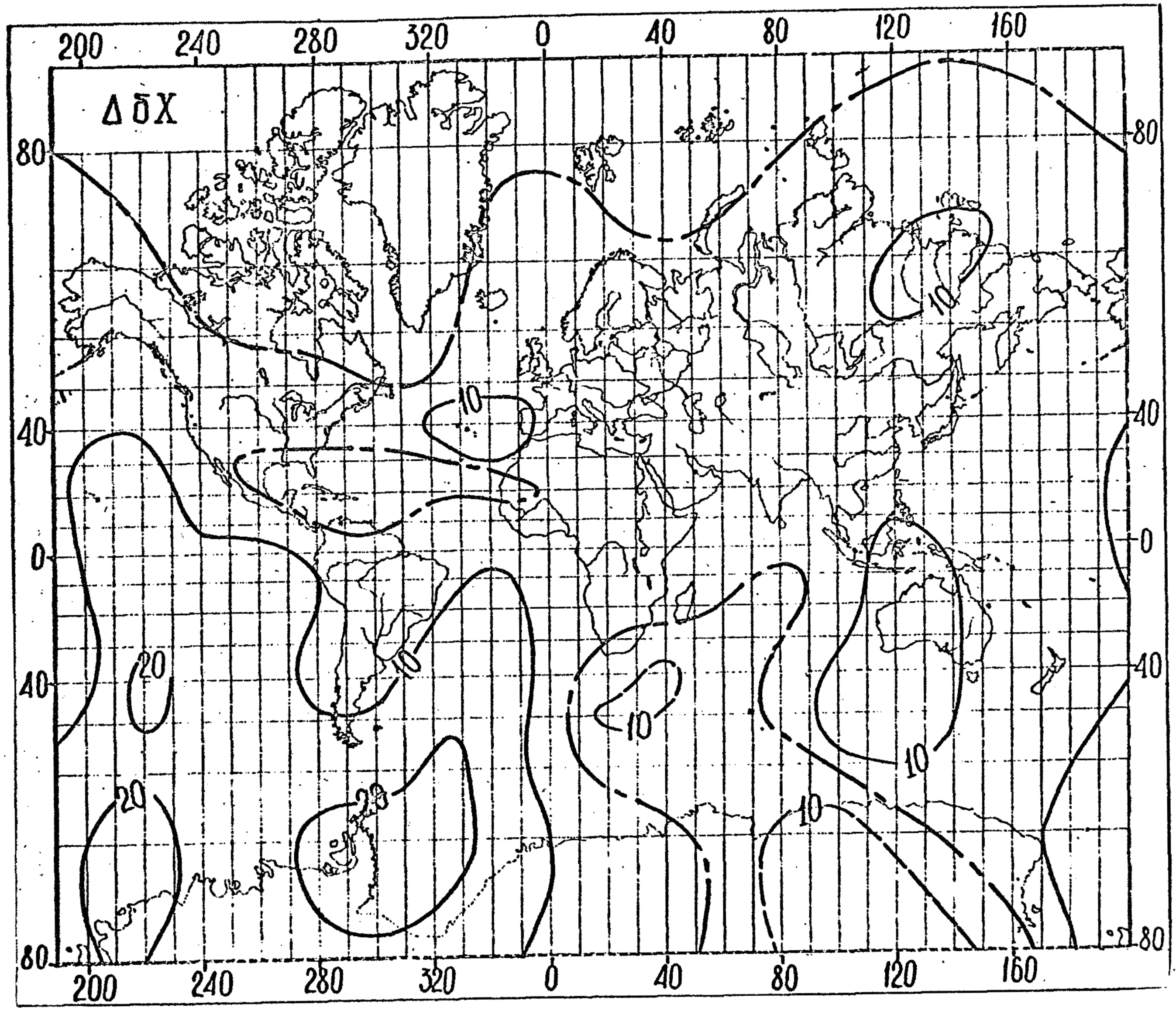


Fig. 14. Differences between graphic and graph-analytic charts of the 1960 - 1965 Periods. (3γ)

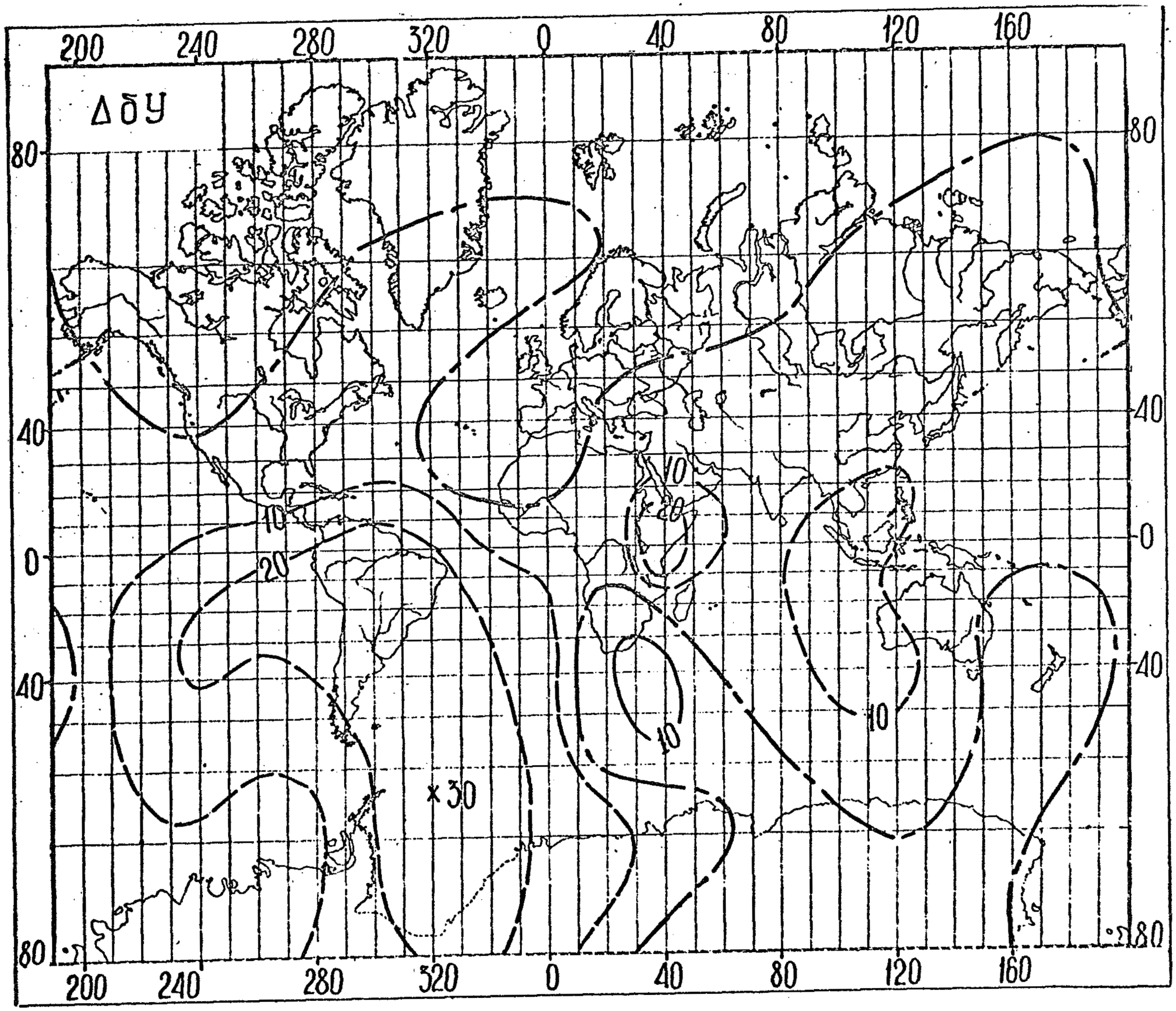


Fig. 15. Differences between graphic and graph-analytic charts of 1960 - 1965 period. (B y)

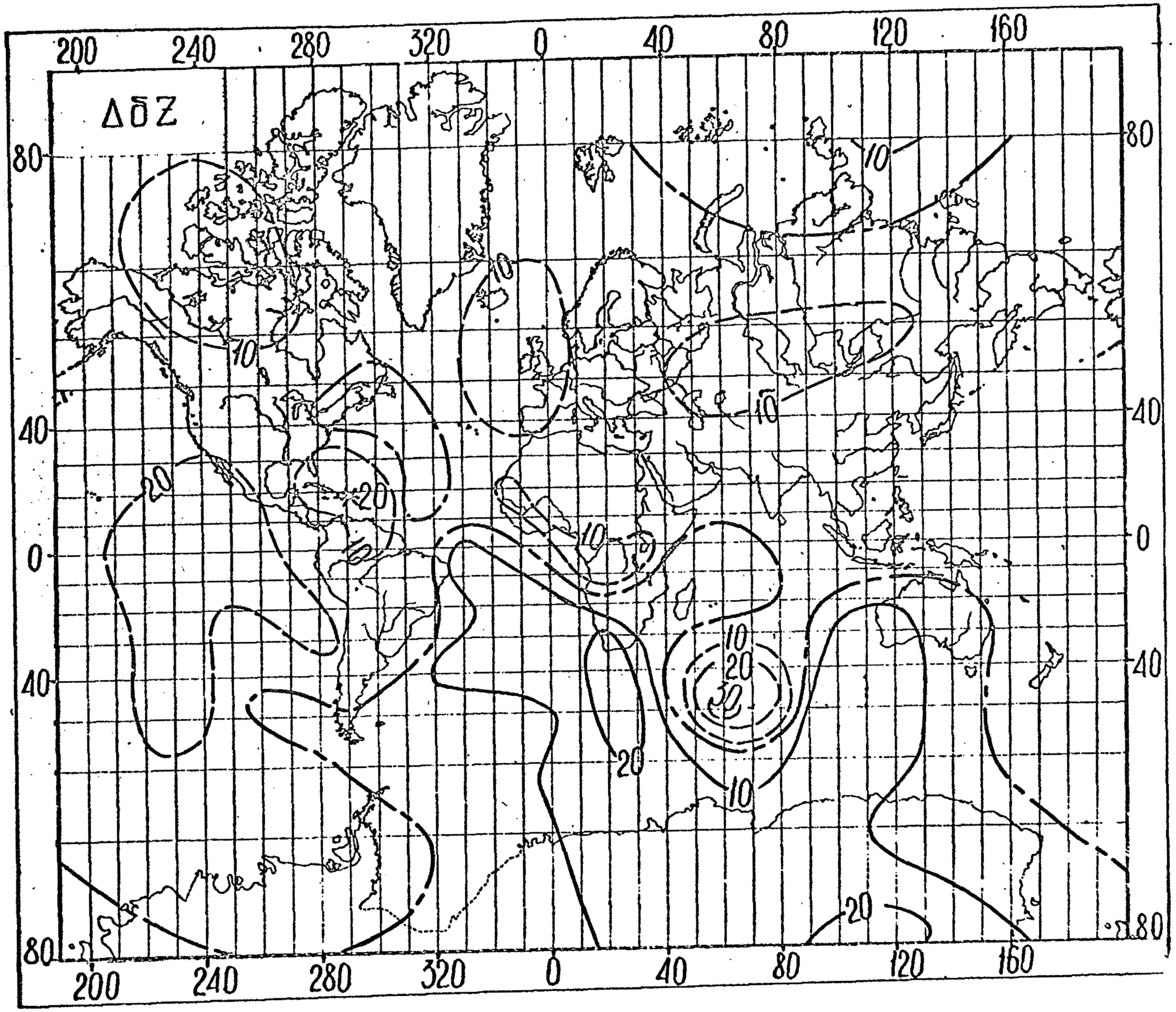


Fig. 16. Differences between graphic and graph-analytic charts for the 1960 - 1965 period. (Bγ)

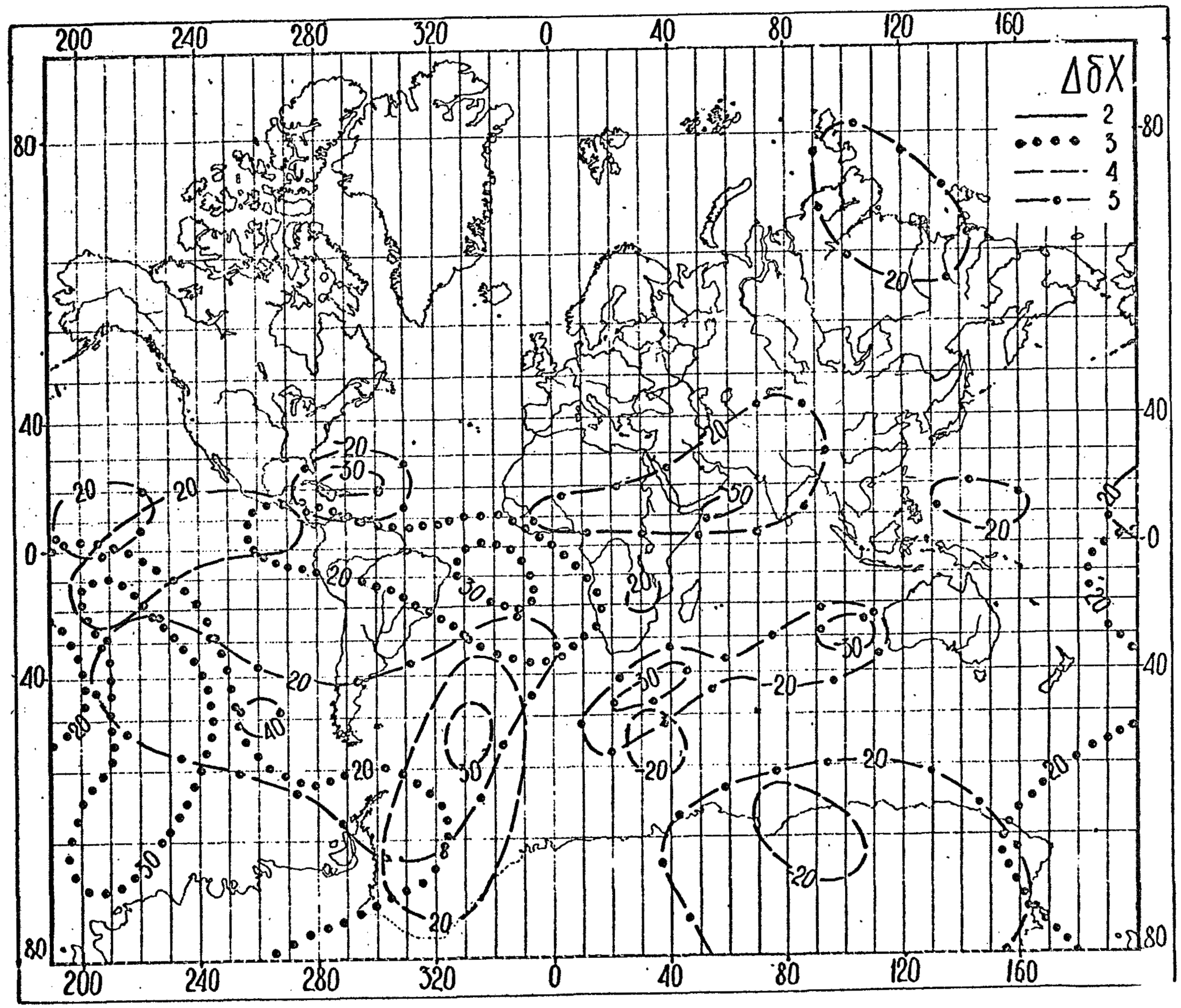


Fig. 17. Differences between SV values of graphic charts and synthesized values with coefficient analysis 2, 3, 4, 5 of Table 4. (By)

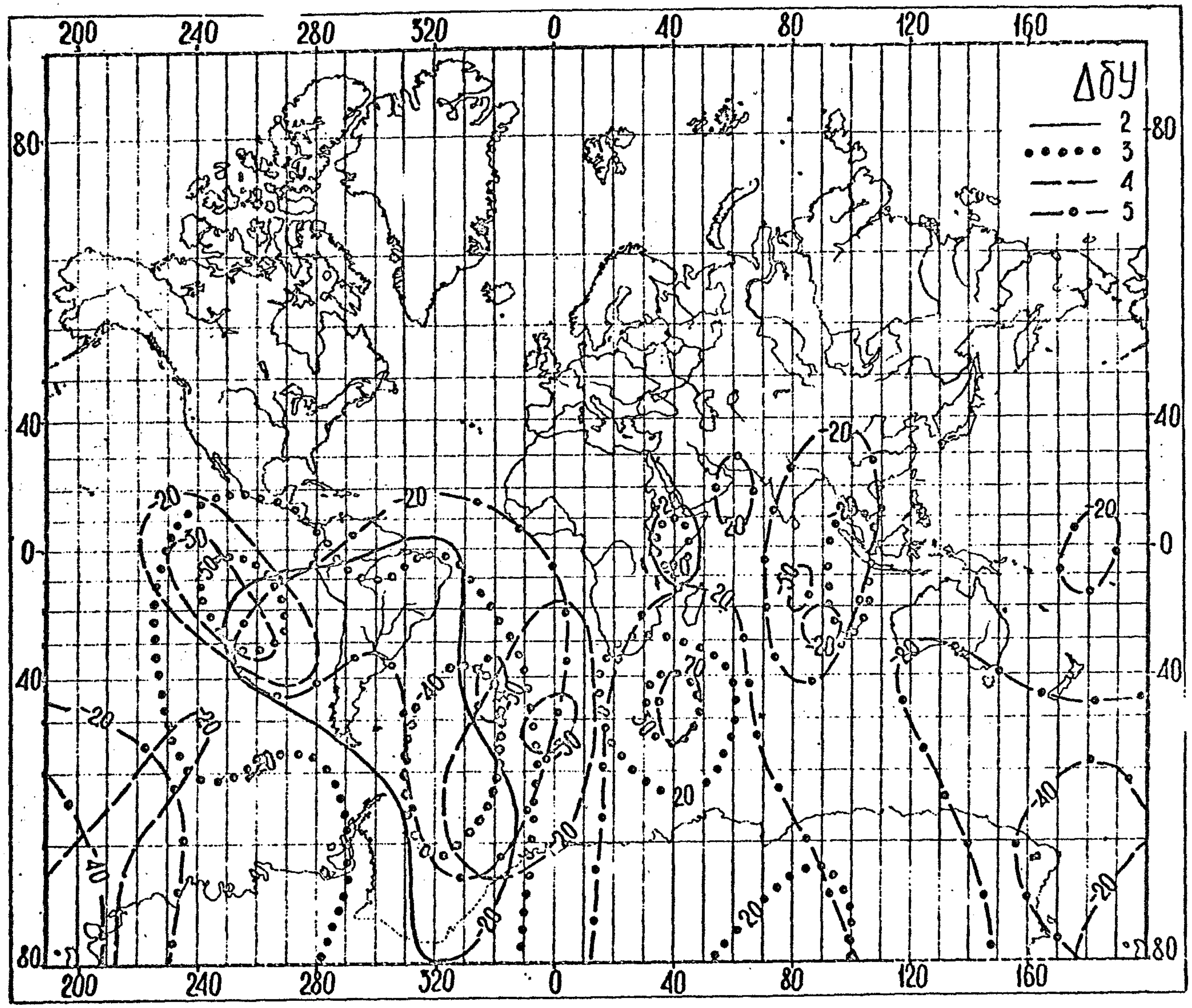


Fig. 18. Difference of SV between graphic chart values and synthesized values by analysis coefficients 2, 3, 4, 5 of table 4. (Bγ)

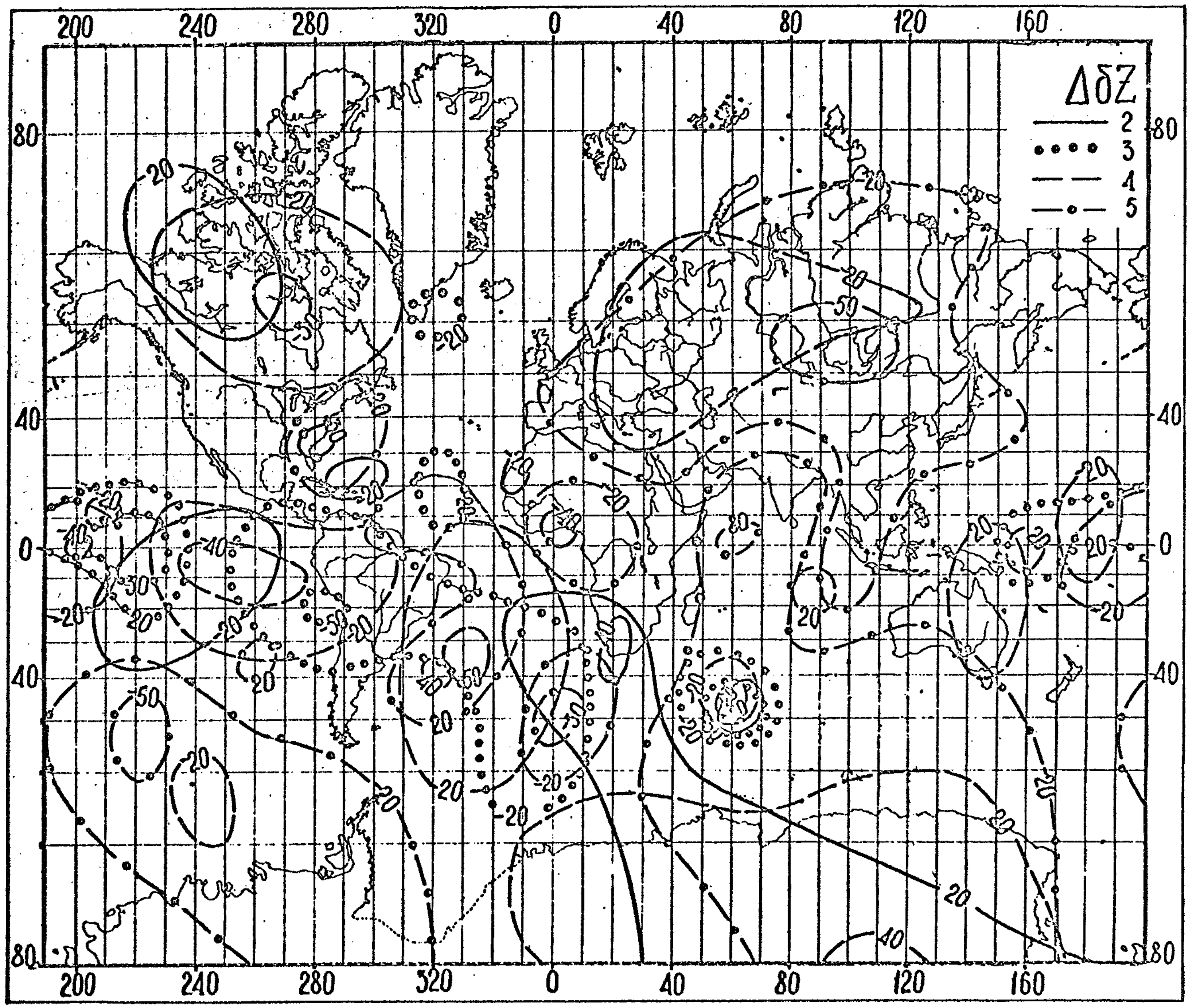


Fig. 19. Difference of SV between graphic chart values and synthesized values by analysis coefficients 2, 3, 4, 5 of table 4. (Bγ)